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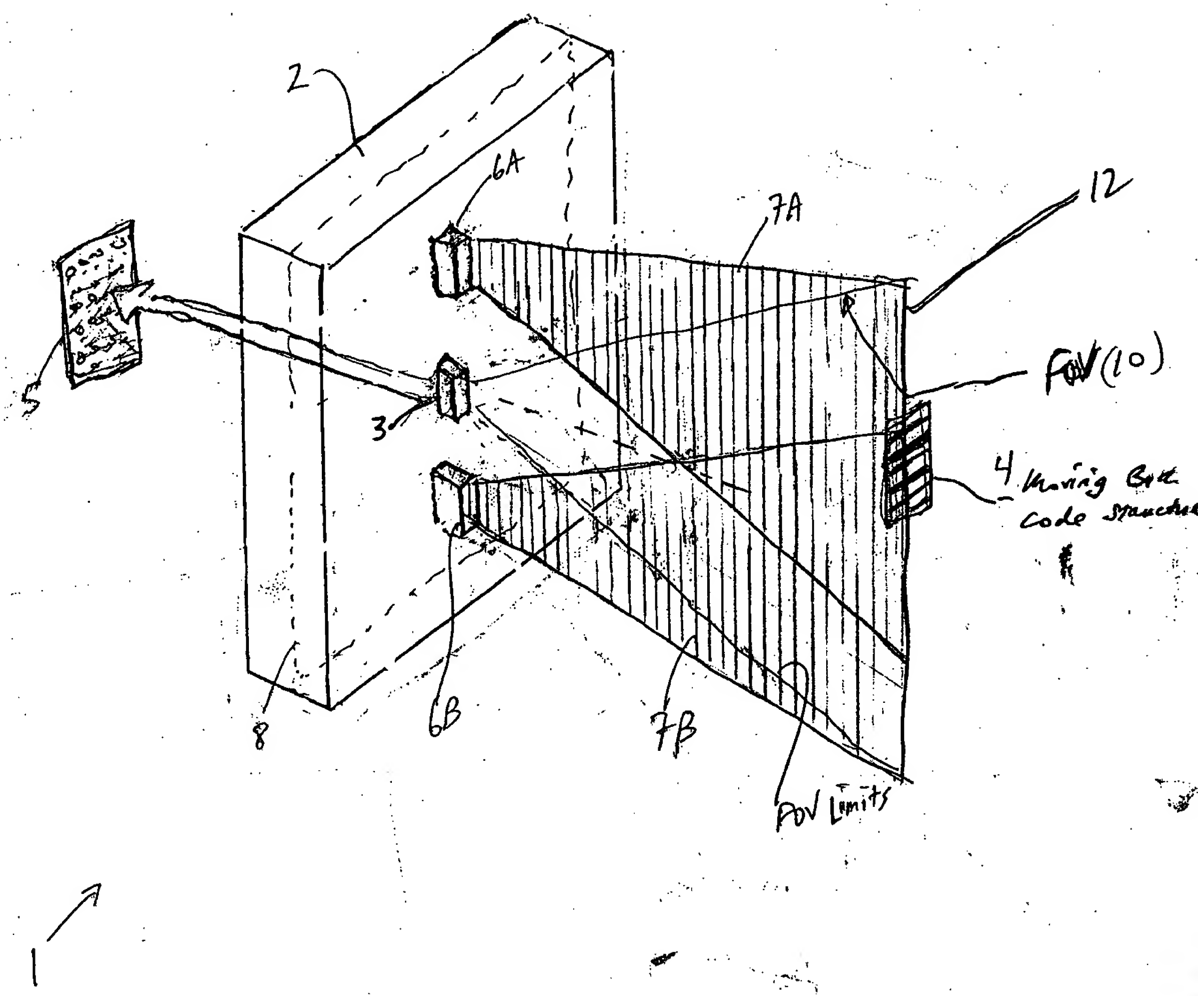

FIG 1A

1/206

108-1064SA000

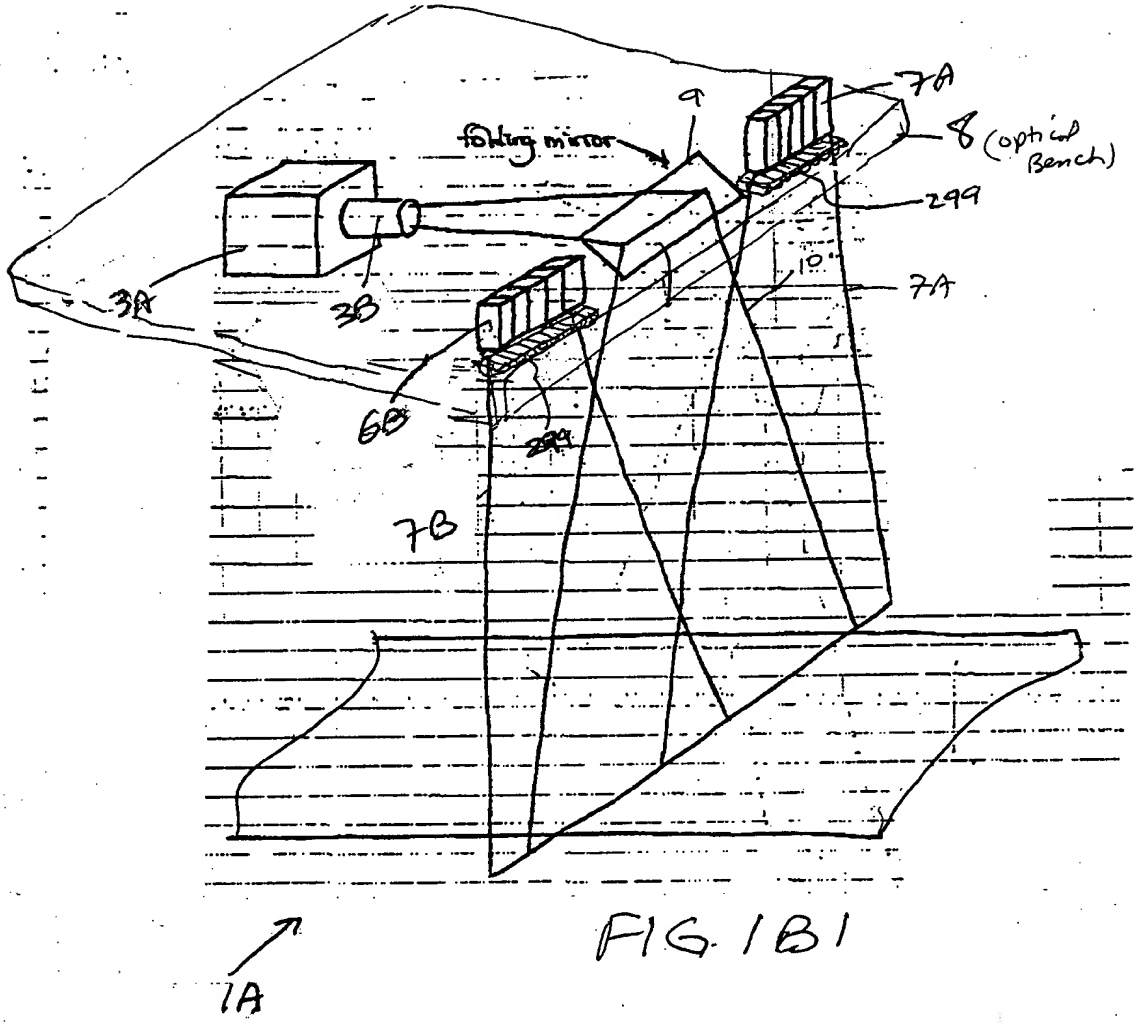

FIG. 1B1

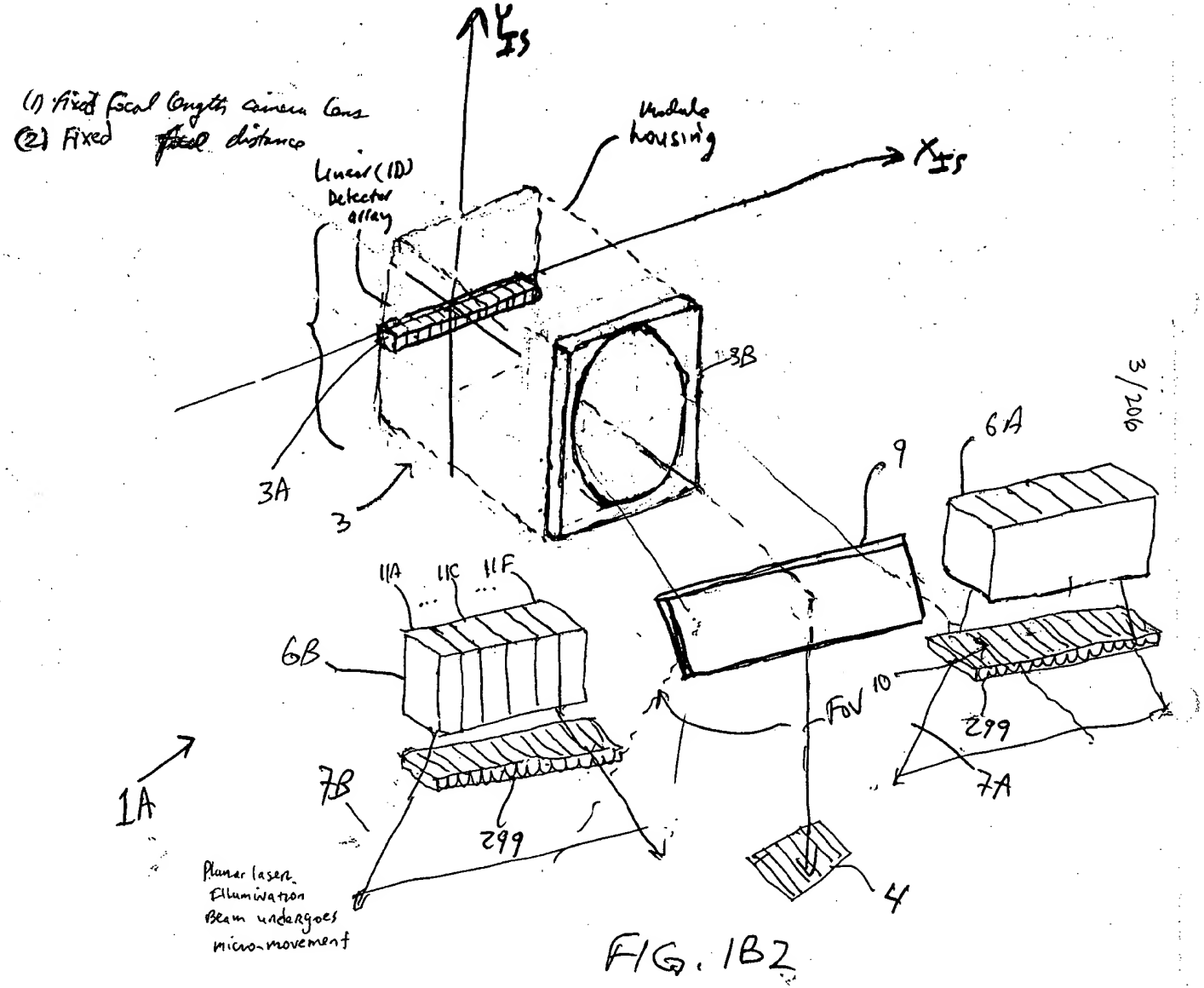
(1) Fixed focal length camera lens
(2) Fixed field distance
Linear (1D) detector array
Module housing
Y_{FS}
X_{FS}
3B
3A
3
9
6A
11A
11C
11F
6B
FOV
10
Z99
7B
7A
1A
Planar laser illumination beam undergoes micro-movement
4

FIG. 1B2

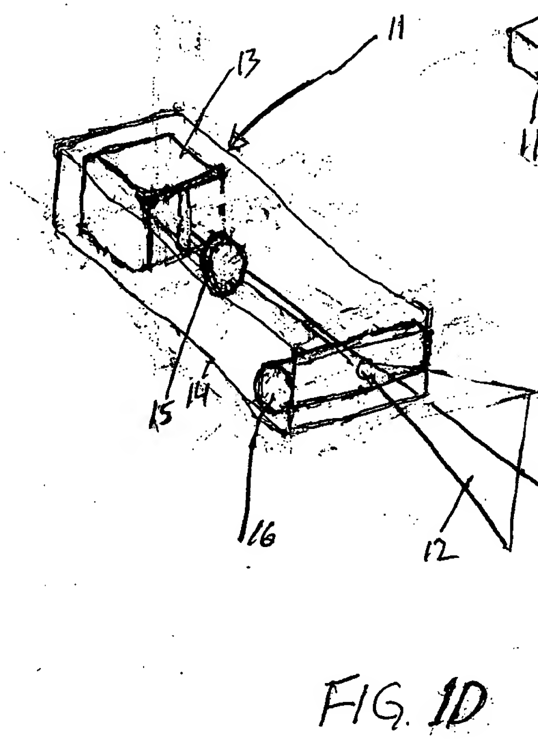

FIG. 1D

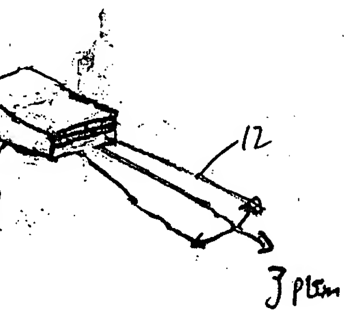

FIG. 1C

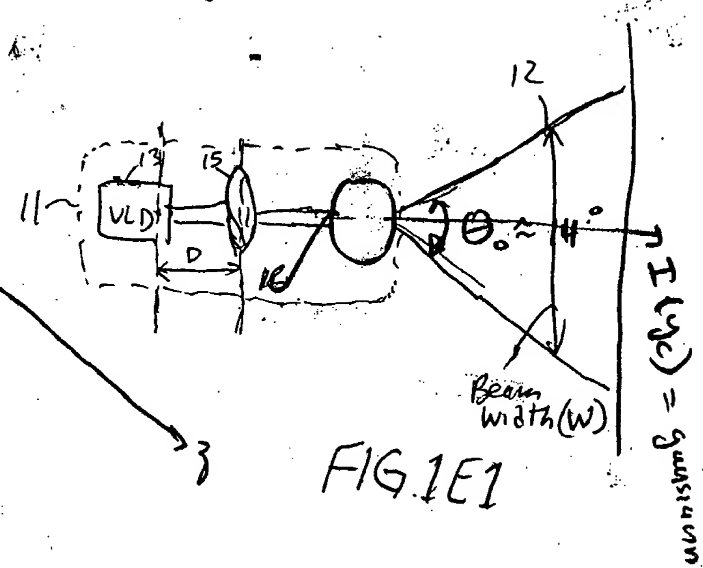

FIG. 1E1

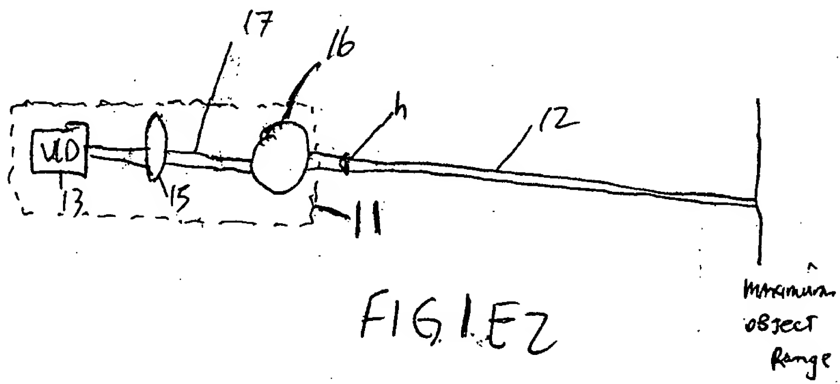

FIG. 1E2

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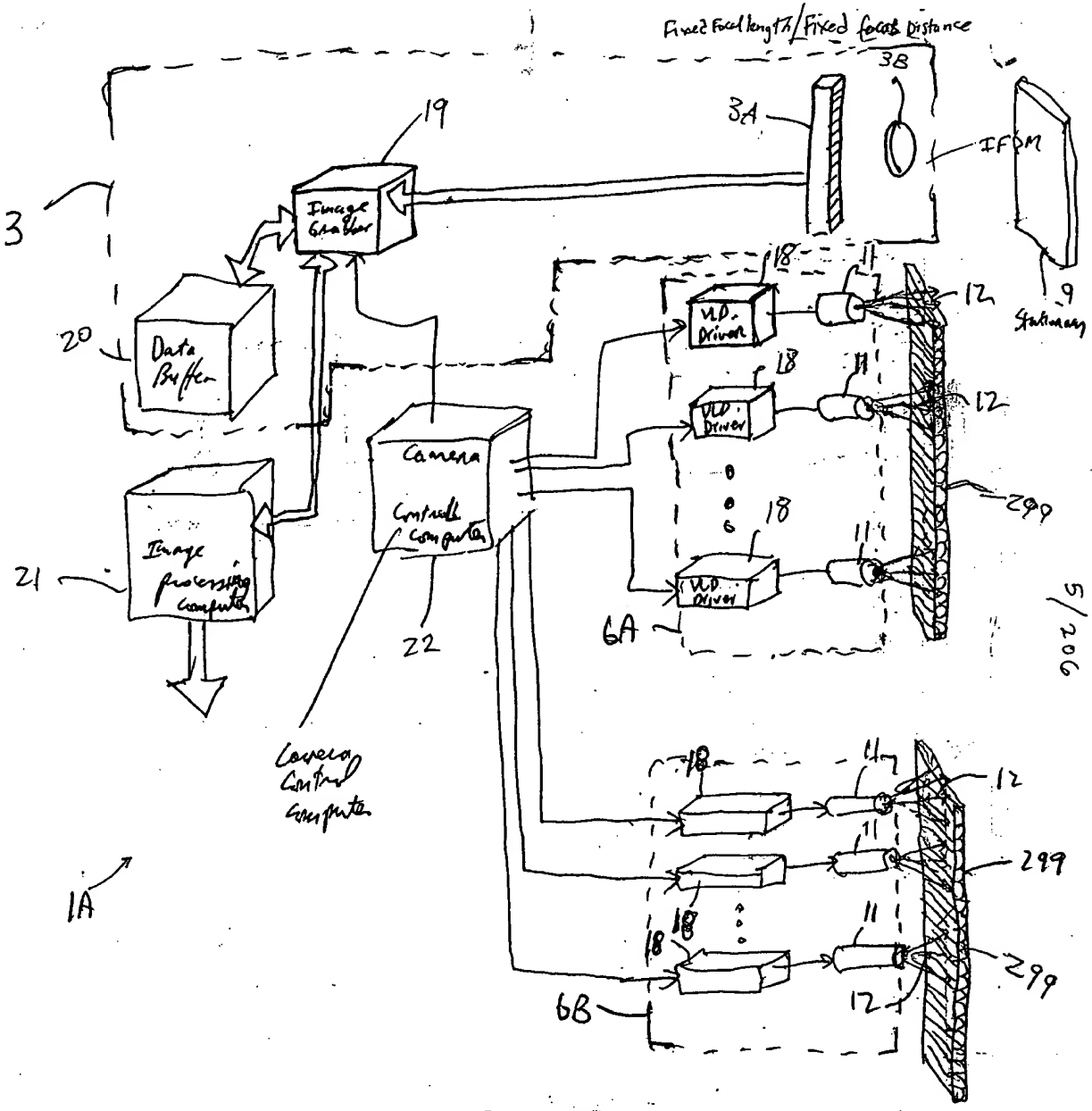

Fixed Focal length/Fixed focus distance
3B
3A
IFOM
19
3
Image Grabber
18
11
12
VLD Driver
9
Stationary
20
Data Buffer
18
11
12
VLD Driver
Camera
Control computer
299
18
11
VLD Driver
21
Image processing computer
22
6A
5/206
Camera Control computer
18
11
12
299
18
18
11
299
12
6B
1A

FIG. 1F

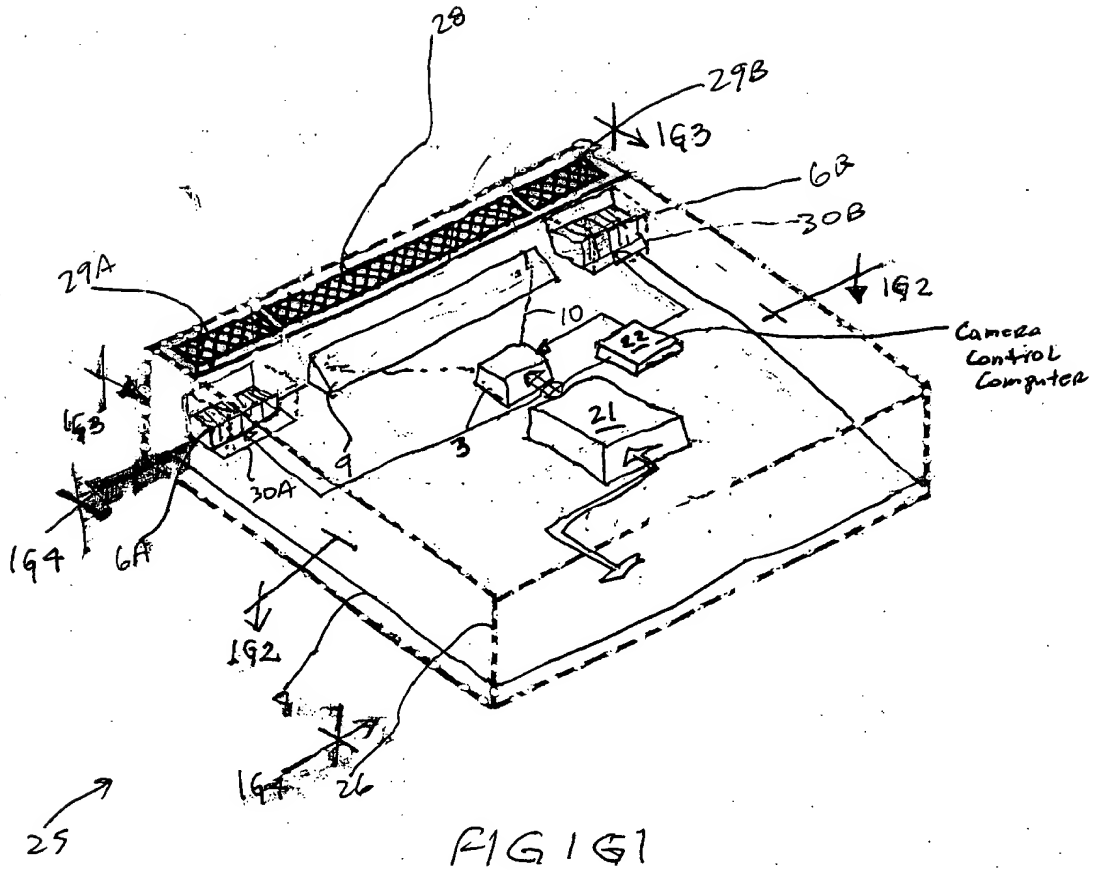

28
29B
IG3
6B
30B
IG2
29A
10
Camera Control Computer
IG3
9
3
21
30A
IG4
6A
IG2
4
IG1
26
25

FIG 1G1

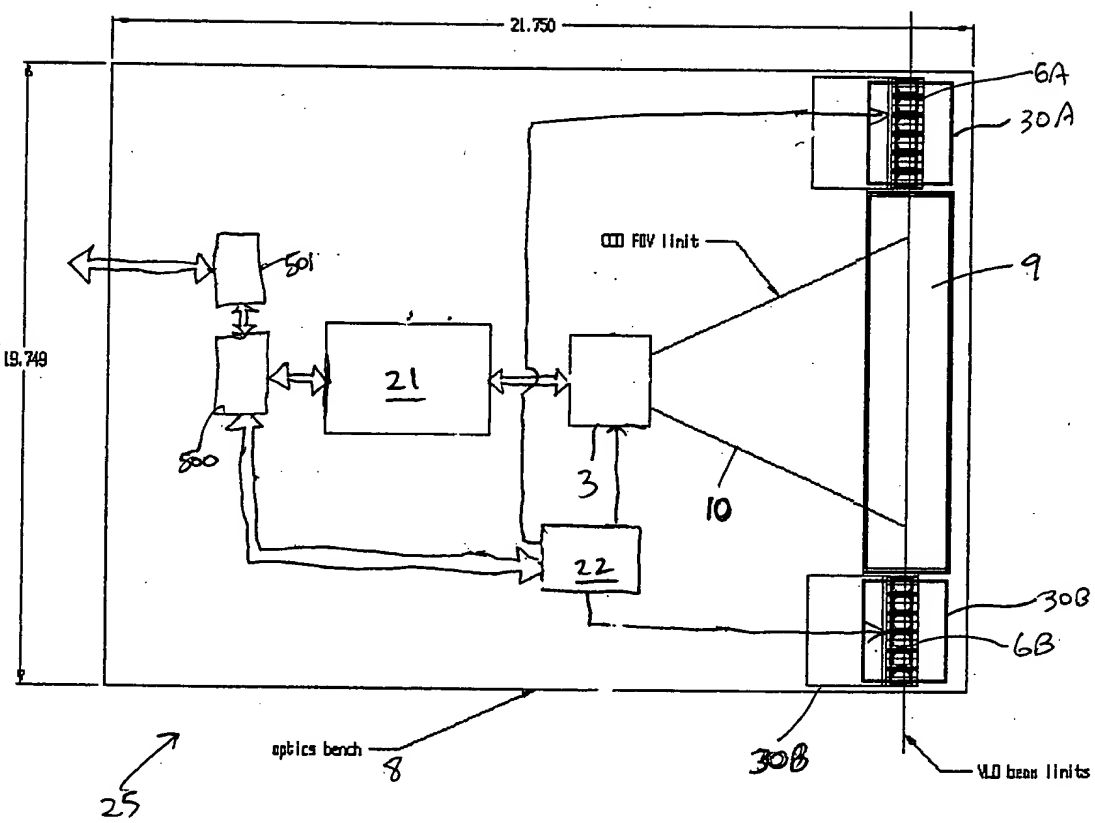

21.750
19.749
6A
30A
FOV limit
9
501
21
500
3
10
22
30B
6B
optics bench
8
25
30B
VLO beam limits

FIG. 1G2

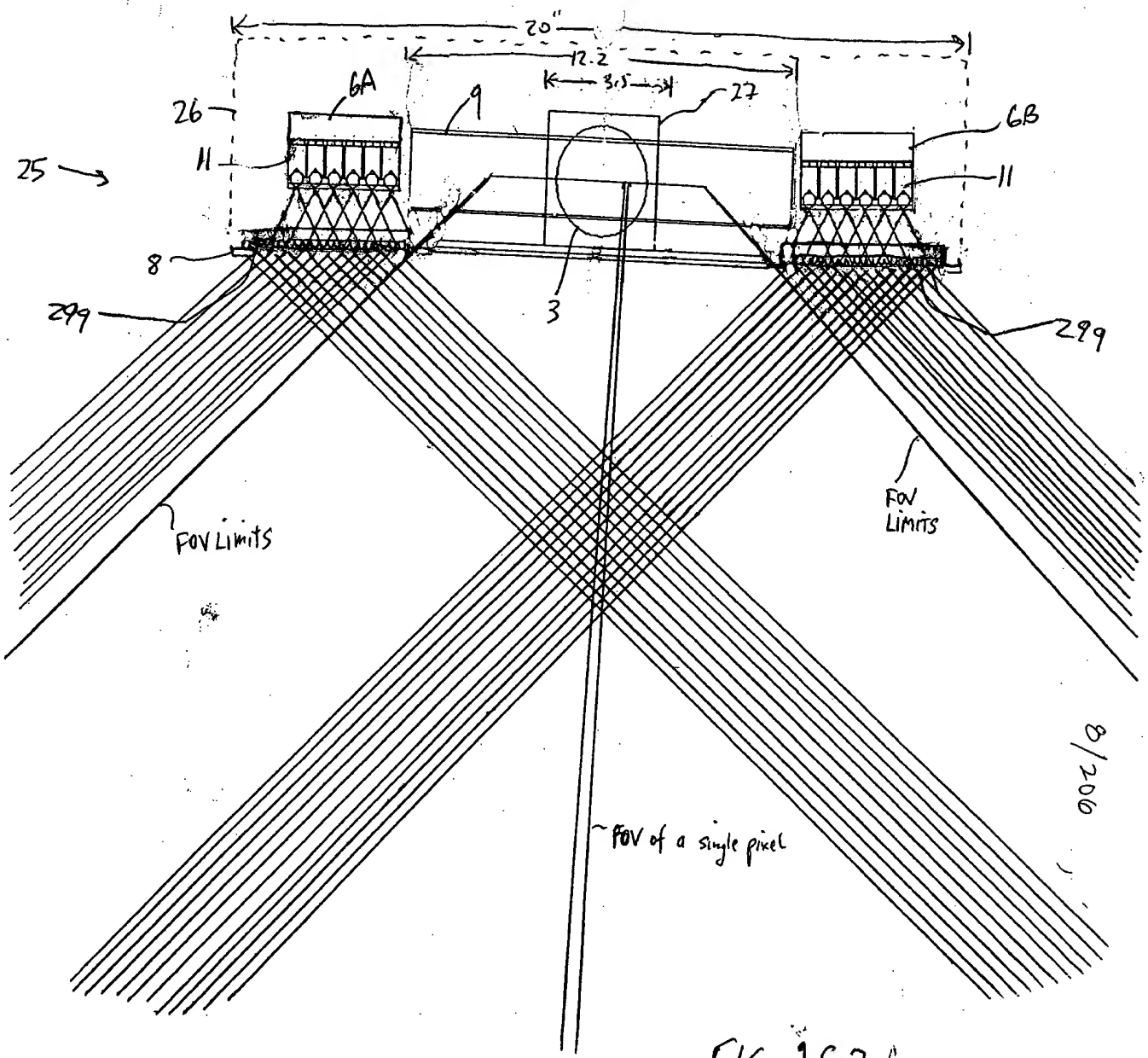


FIG. 1G3

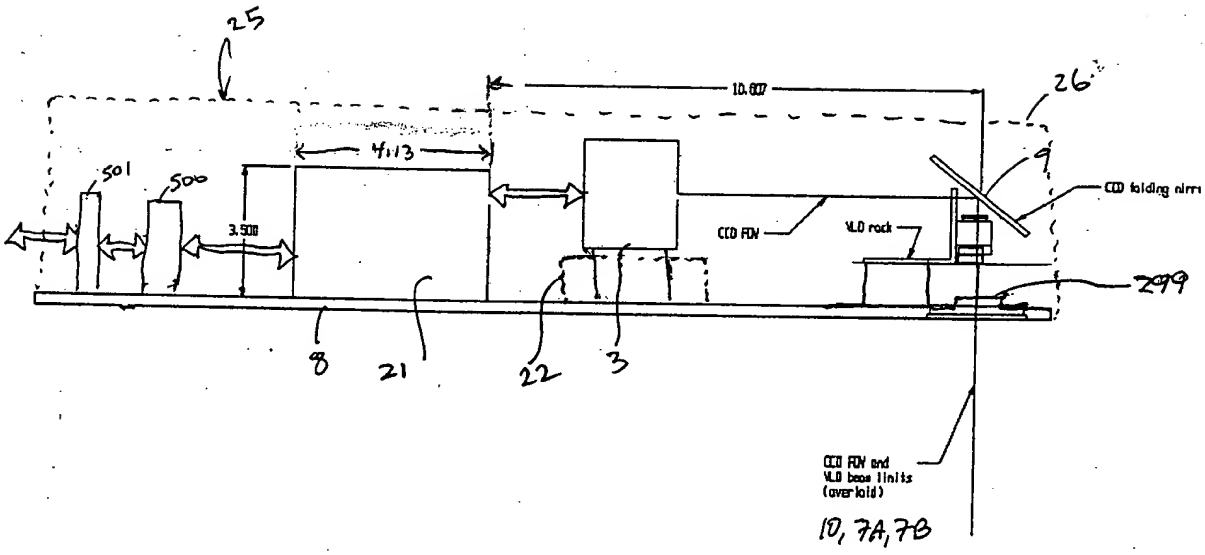
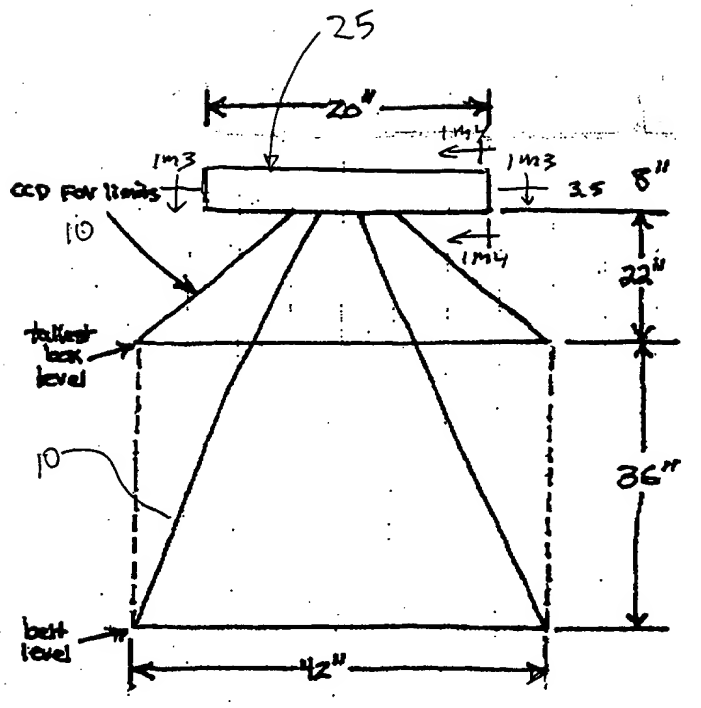

25
10.607
26
4.113
501
500
3.500
9
CCD folding mirr
CCD FOV
VLD rack
299
8
21
22
3
CCD FOV and
VLD base limits
(overlaid)
10, 7A, 7B

FIG. 164



* Fixed Field of Field

FIG. 165

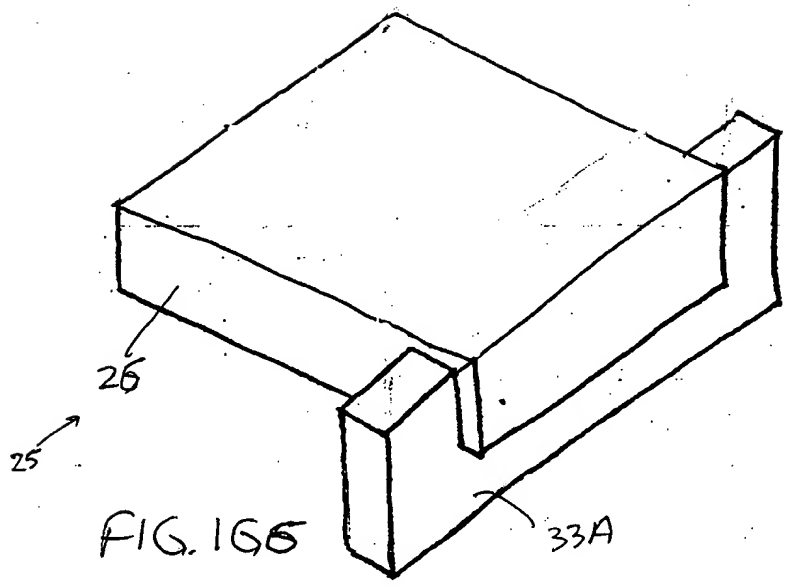


FIG. 16

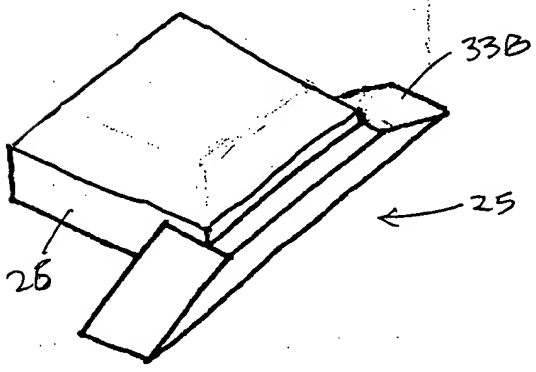


FIG. 17

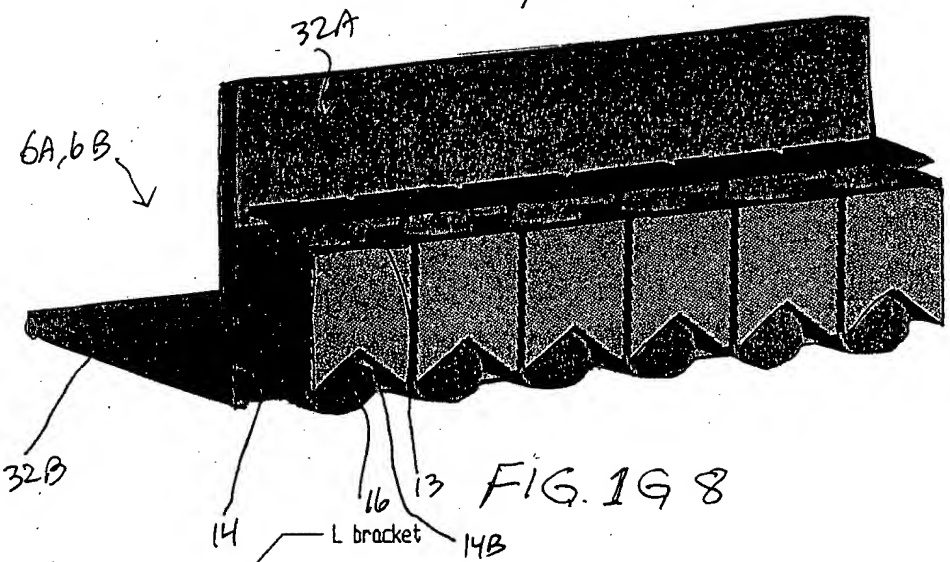


FIG. 1G 8

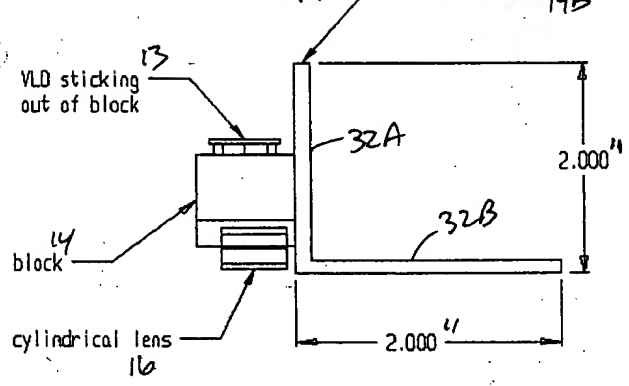


FIG. 1G. 9

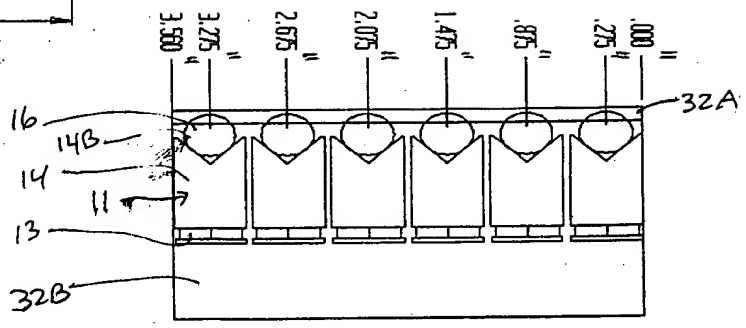


FIG. 1G10

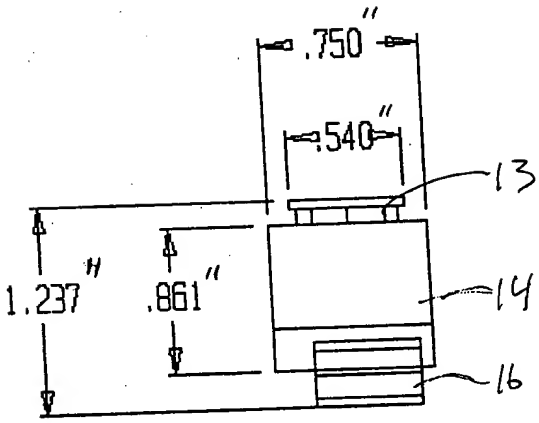


FIG. 16 11

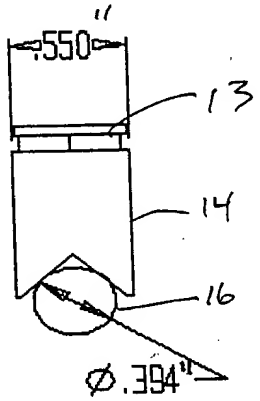


FIG. 16 12

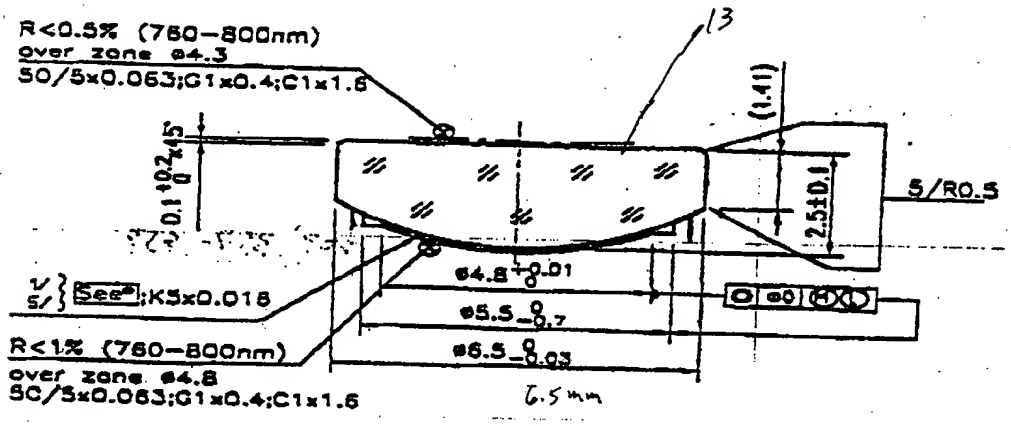


FIG. 1G13

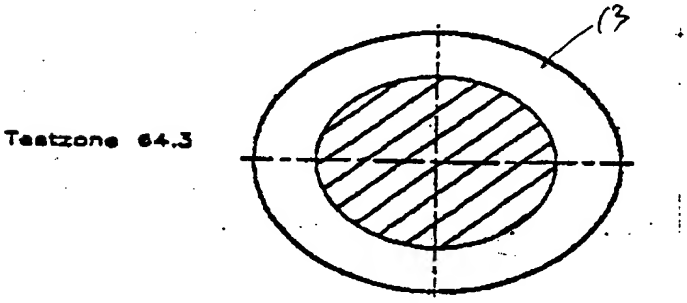


FIG. 1G14

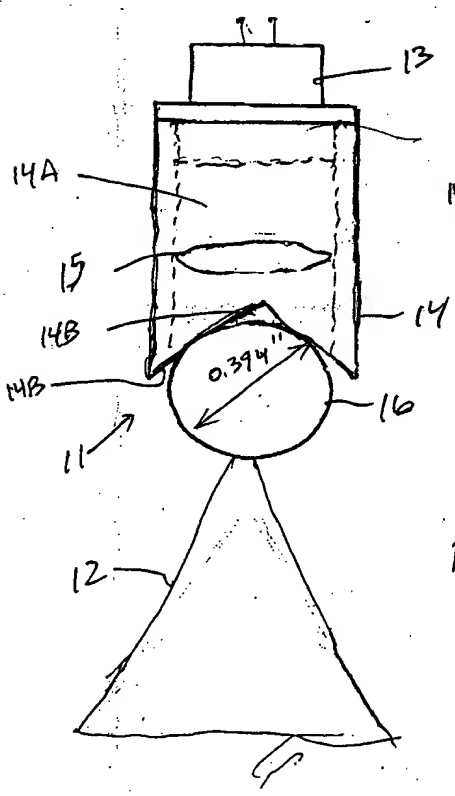


FIG. 1G15A

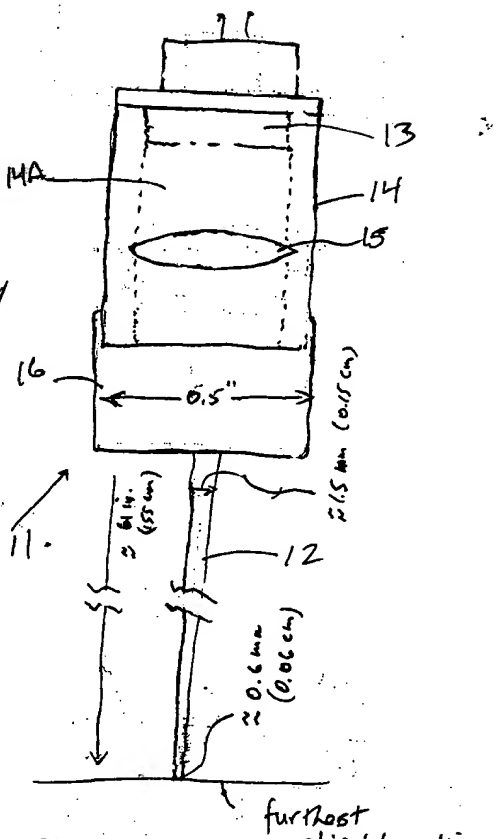


FIG. 1G15B

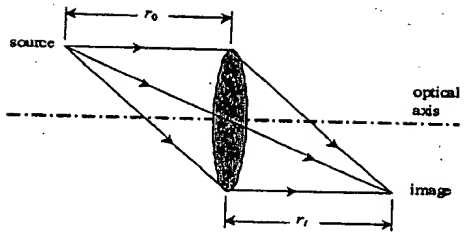


FIG. 1H1

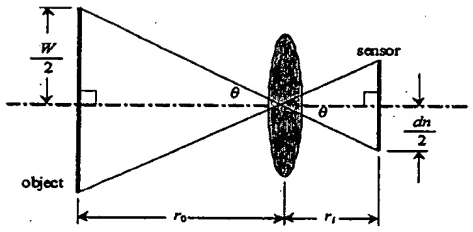


FIG. 1H2

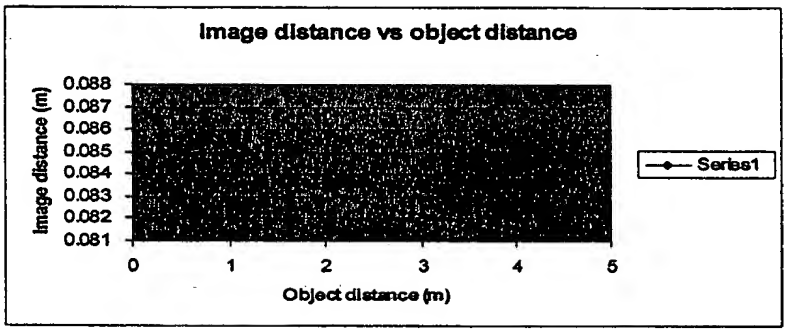


FIG. 1H3

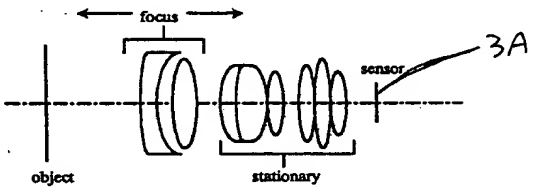


FIG. 1H4

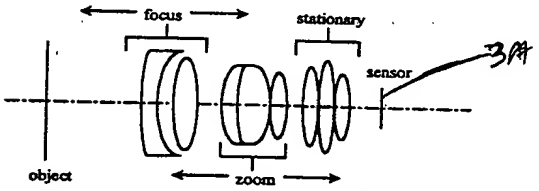


FIG. 1H5

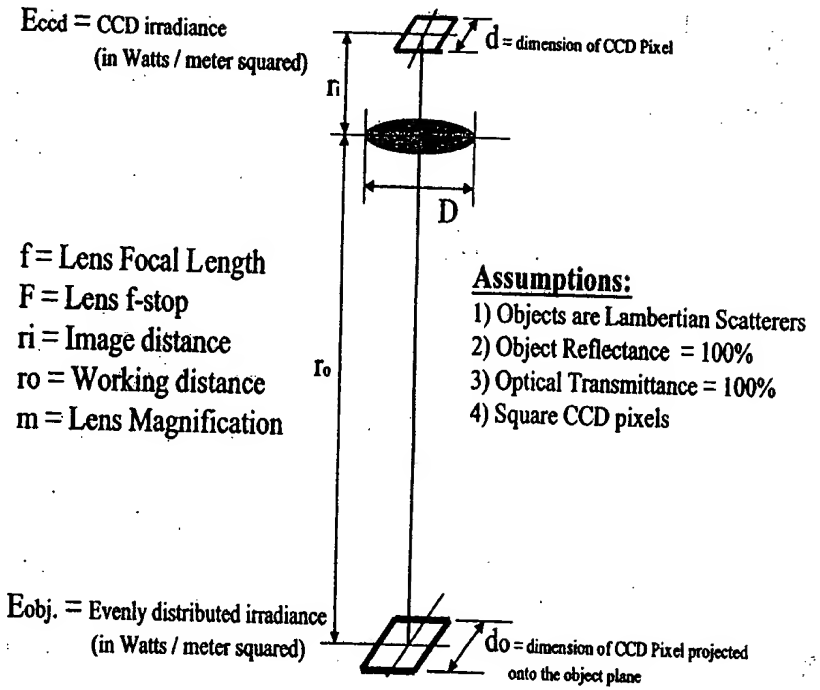


FIG. 1H6

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FIRST GENERALIZED METHOD of Reducing Speckle-Noise Patterns AT Image Detection array of the IFD Subsystem (3)

(SPMF)

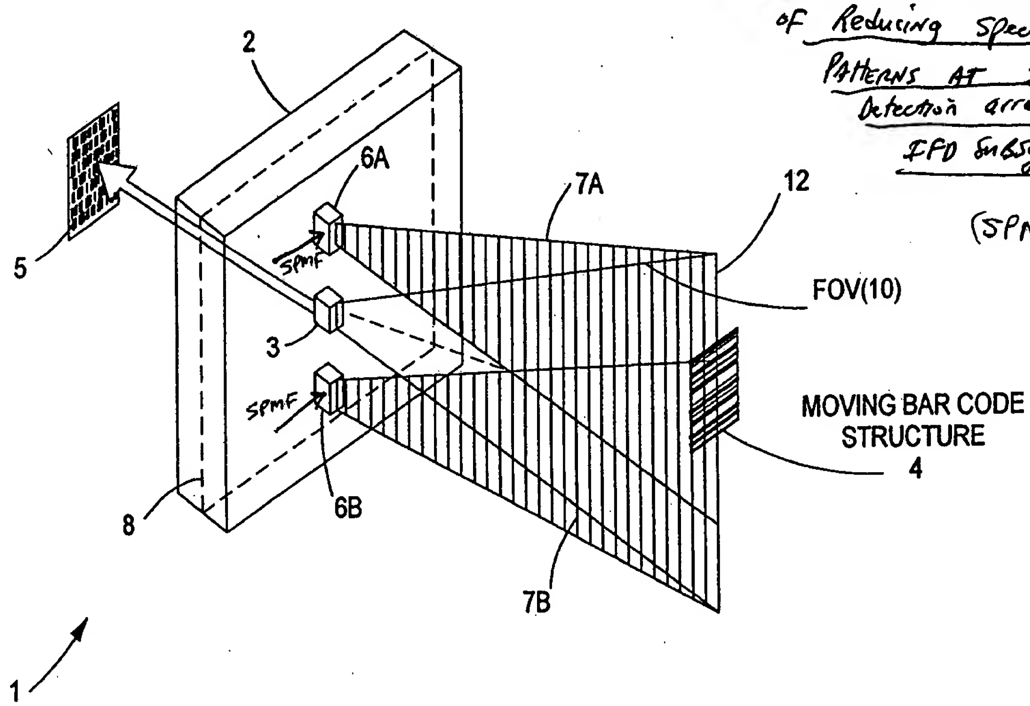


FIG. 1I1

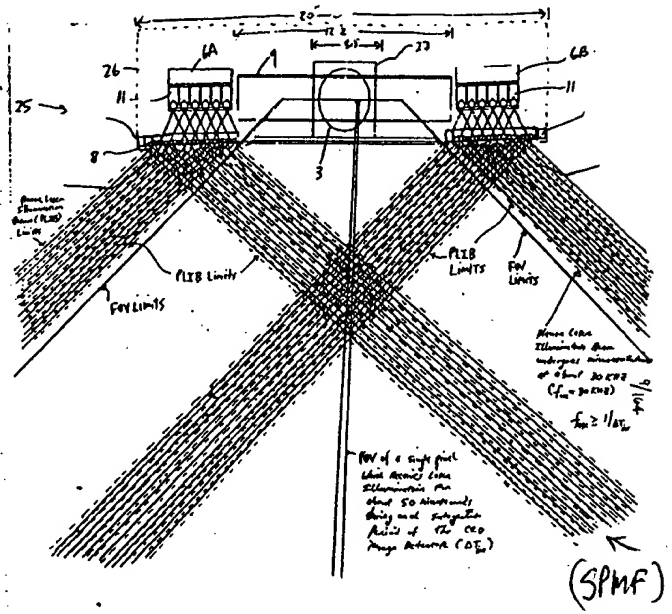


FIG. 11:2A

Prior to object illumination

The First Generalized Speckle-Noise Pattern Reduction Method Of The Present Invention

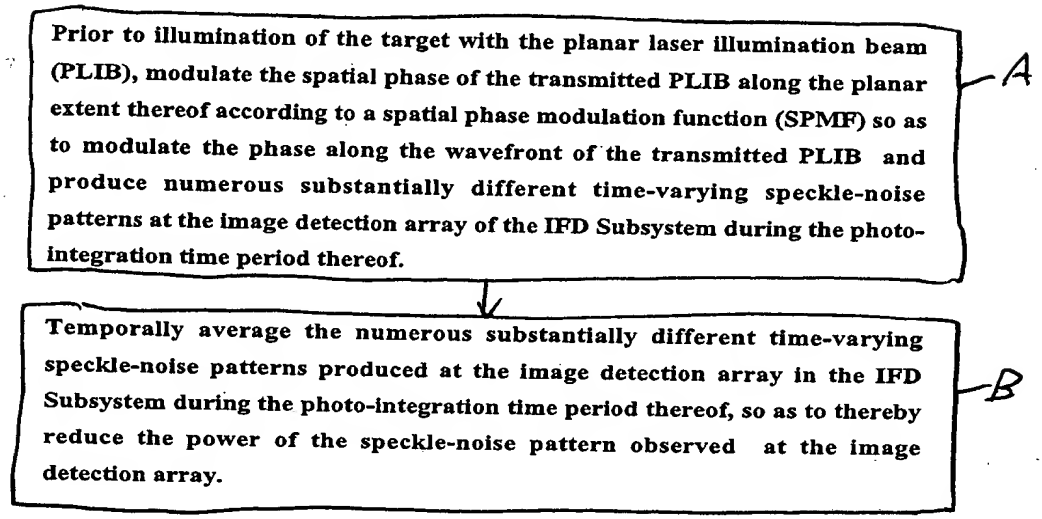


FIG. 1I2B

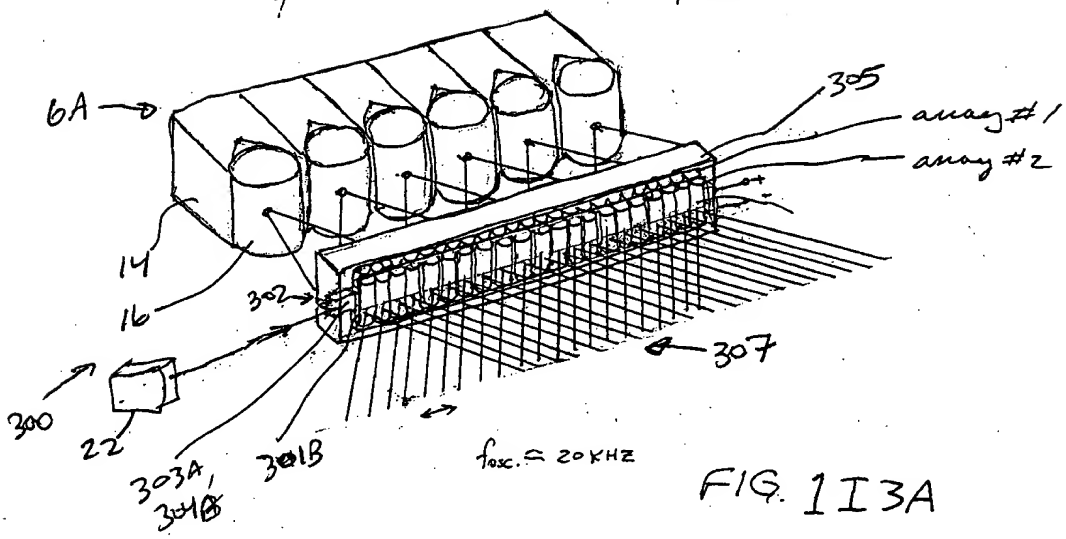


FIG. 1I3A

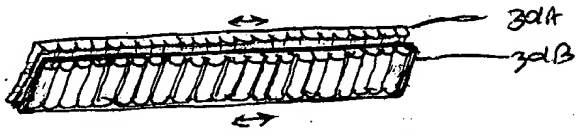


FIG. 1I3B

FIG. 1I3C

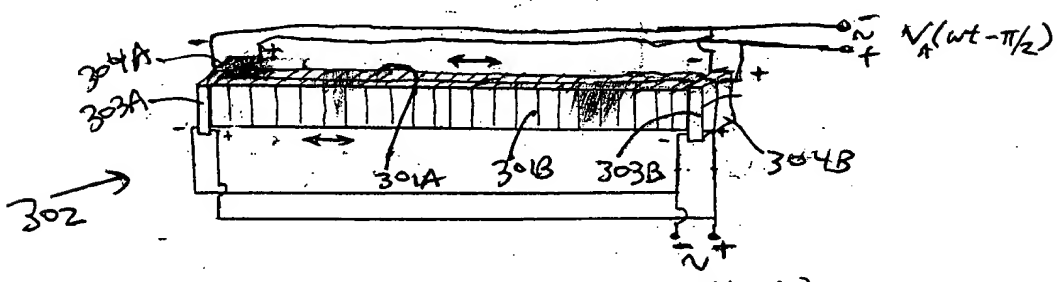


FIG. 1I3D

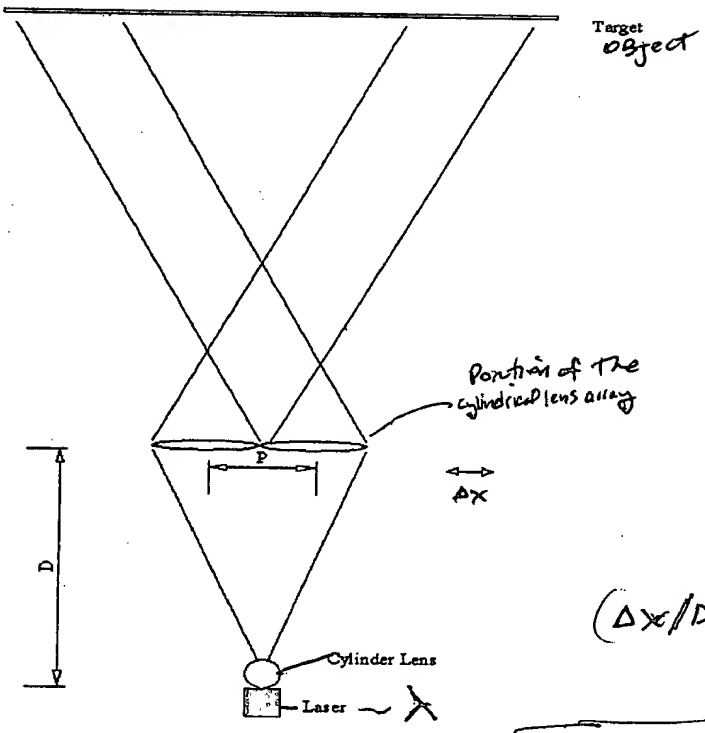


Figure 1

$(\Delta x / D) P = \lambda$

$$\Delta x \geq \frac{\lambda}{P} \cdot D$$

FIG. 1I3E

FIG. 1I3F

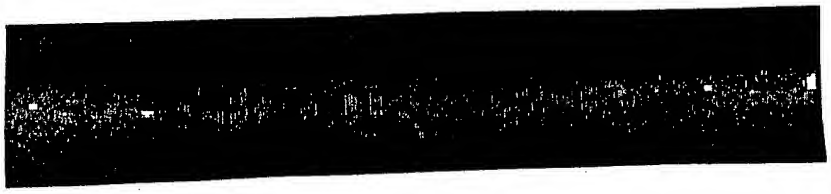


FIG 1I3G

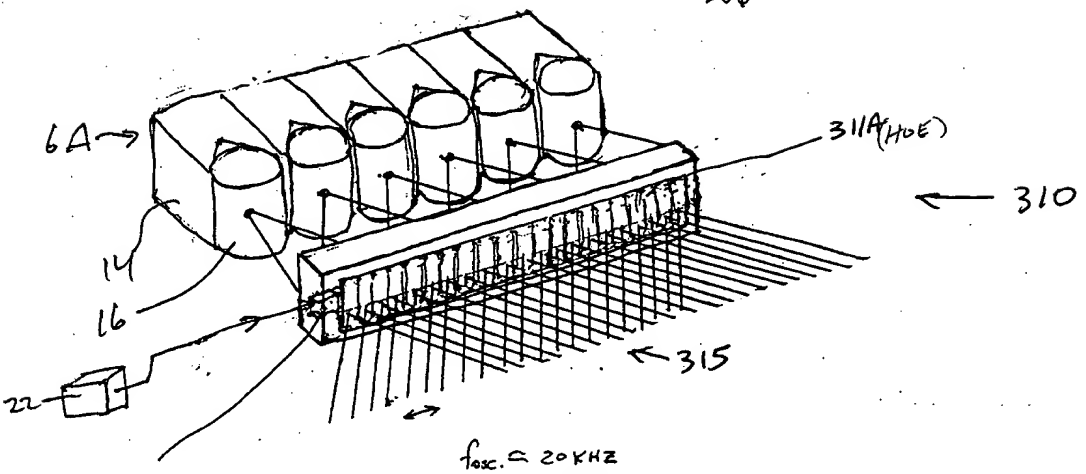


FIG 1I4A

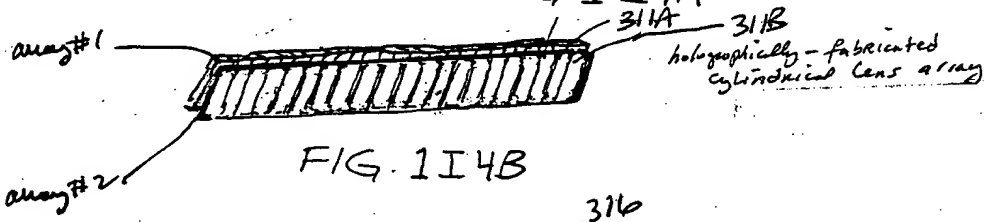


FIG. 1I4B

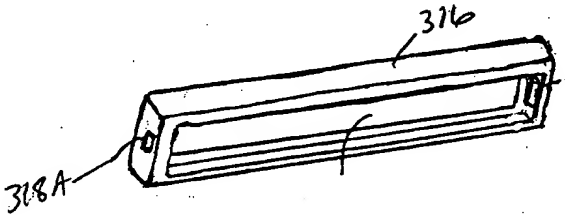


FIG 1I4C

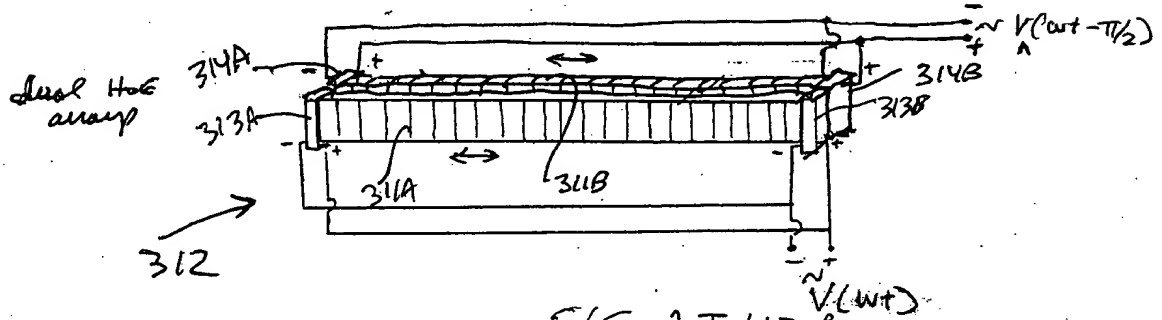


FIG. 1I4D

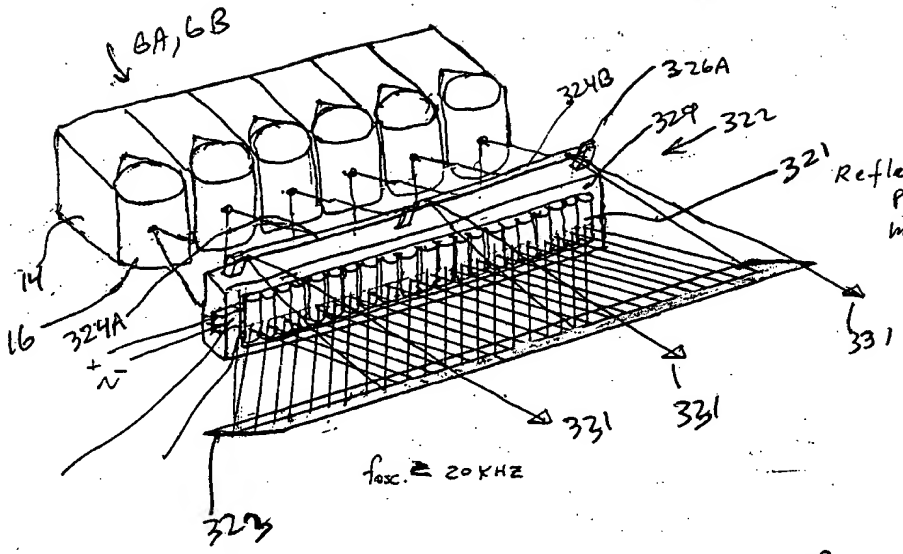


FIG. 1I5A

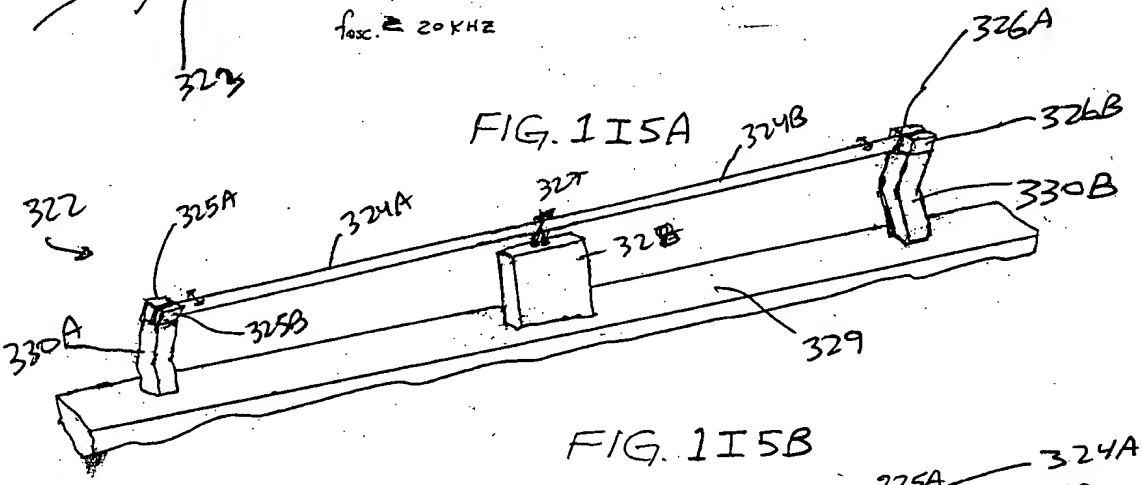


FIG. 1I5B

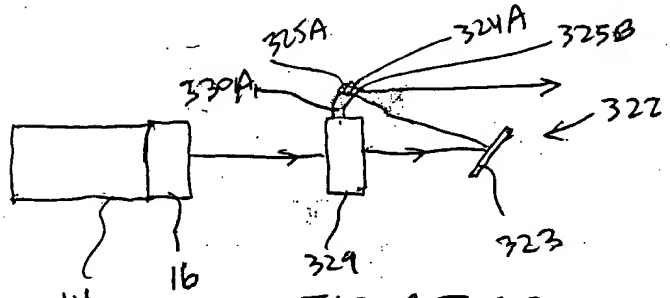


FIG. 1I5C

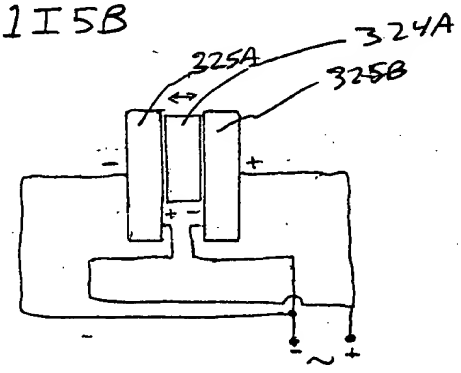


FIG. 1I5D

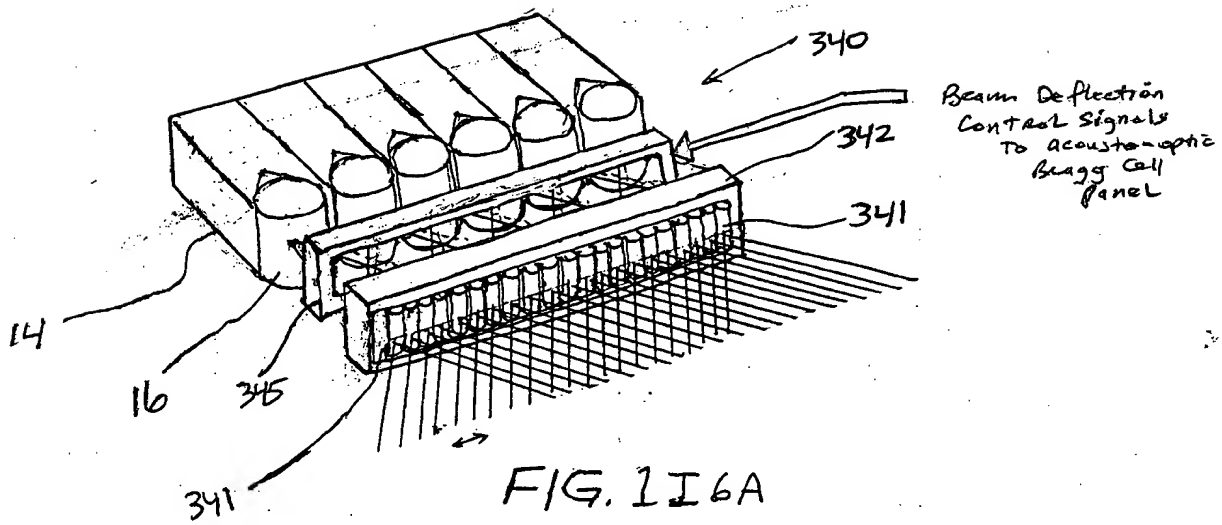


FIG. 1I6A

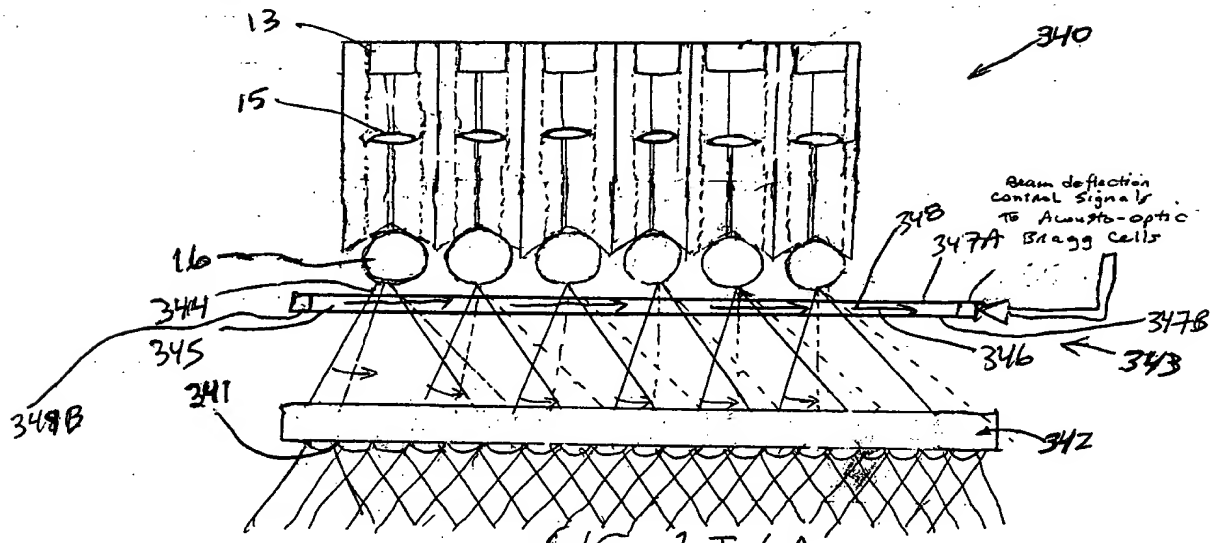


FIG. 1I6A

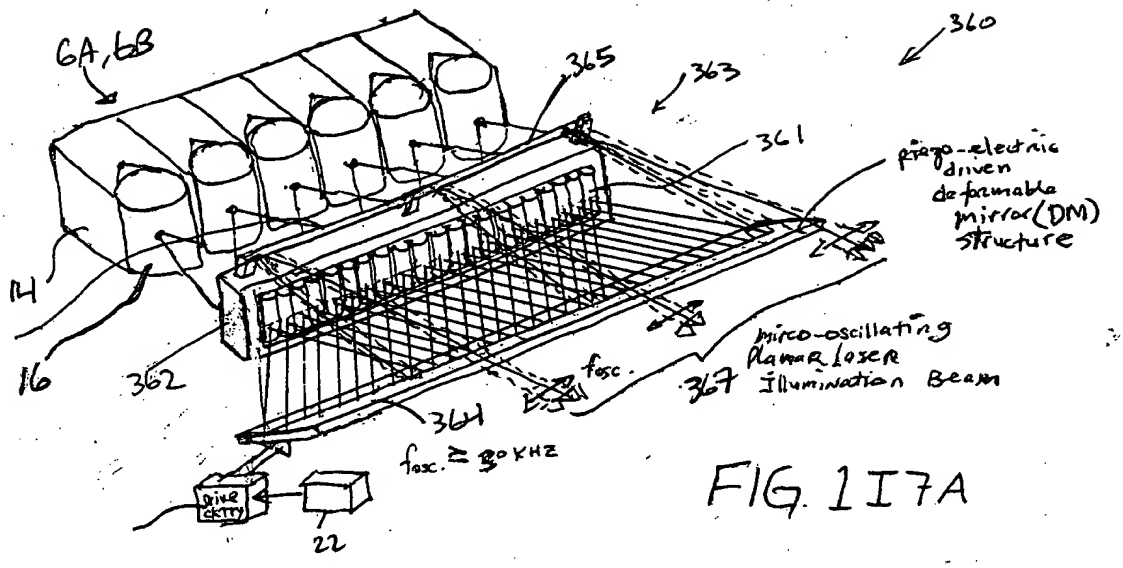


FIG. 1I7A

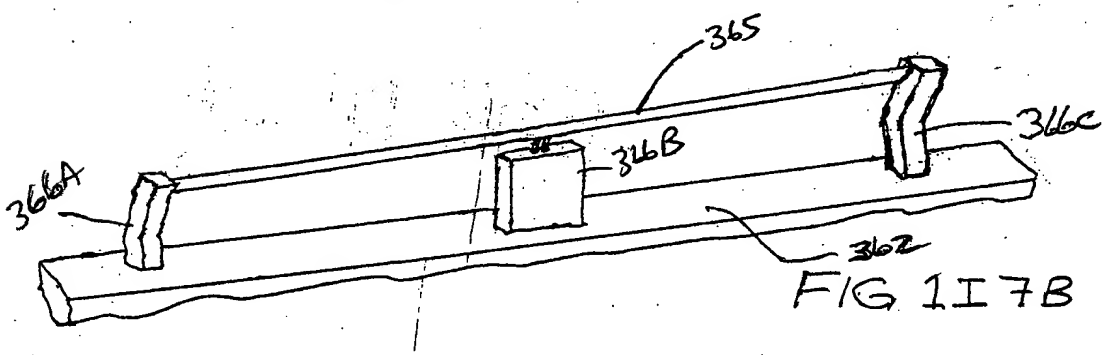


FIG. 1I7B

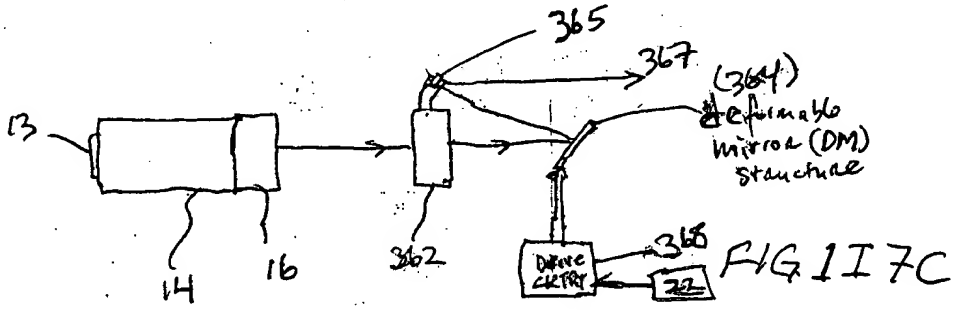


FIG 1I7C

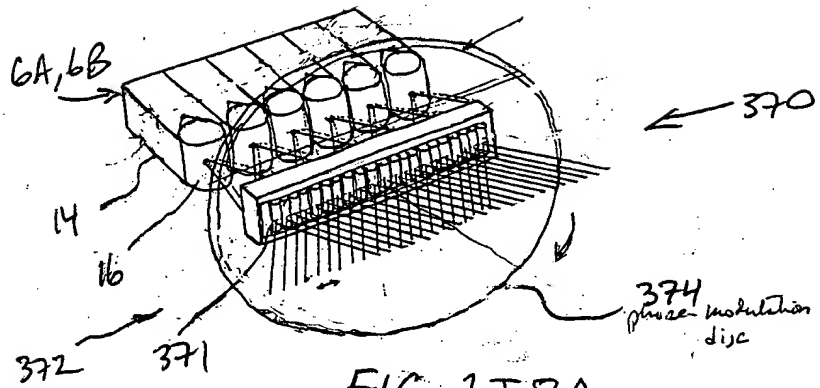


FIG. 1I8A

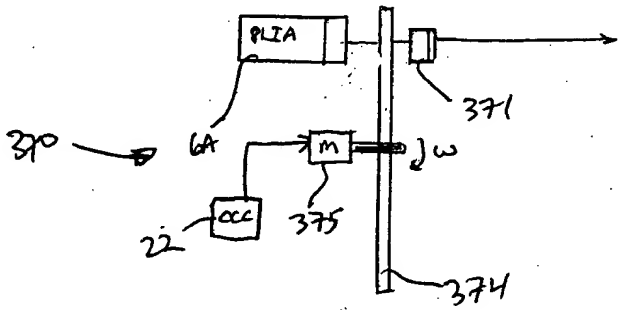


FIG. 1I8B

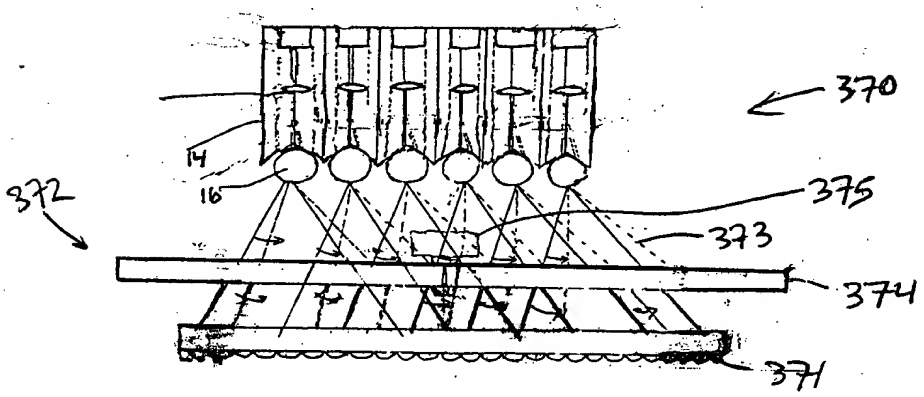


FIG. 1I8C

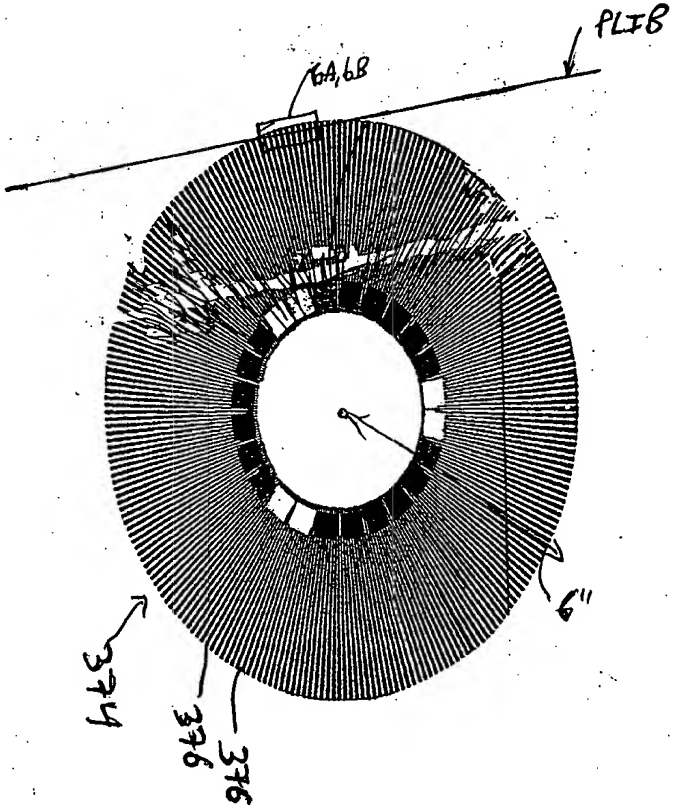


FIG 1I8D

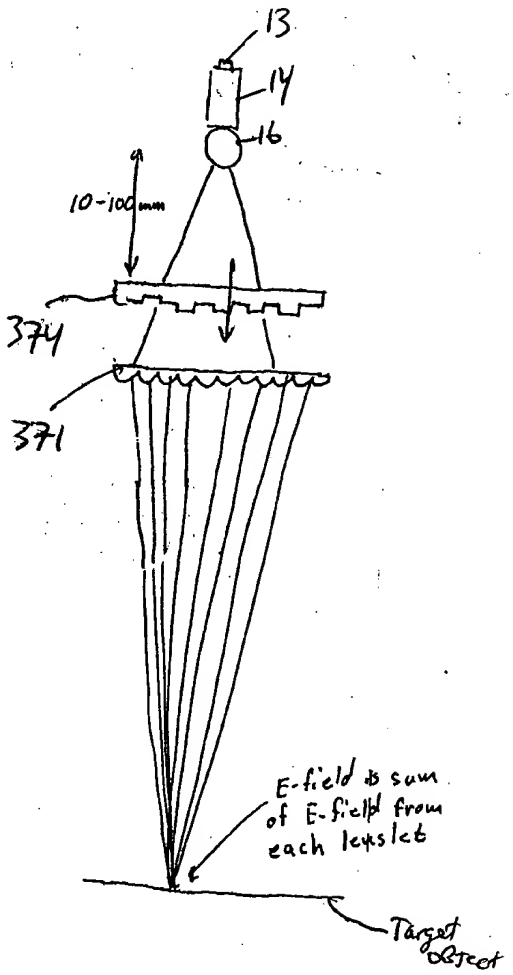


FIG 1I8E

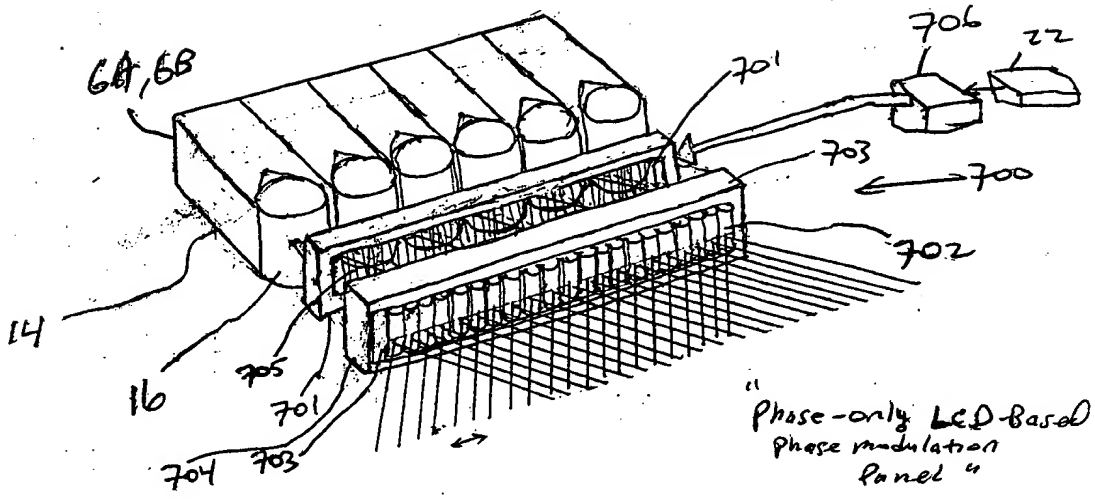


FIG.1I8F

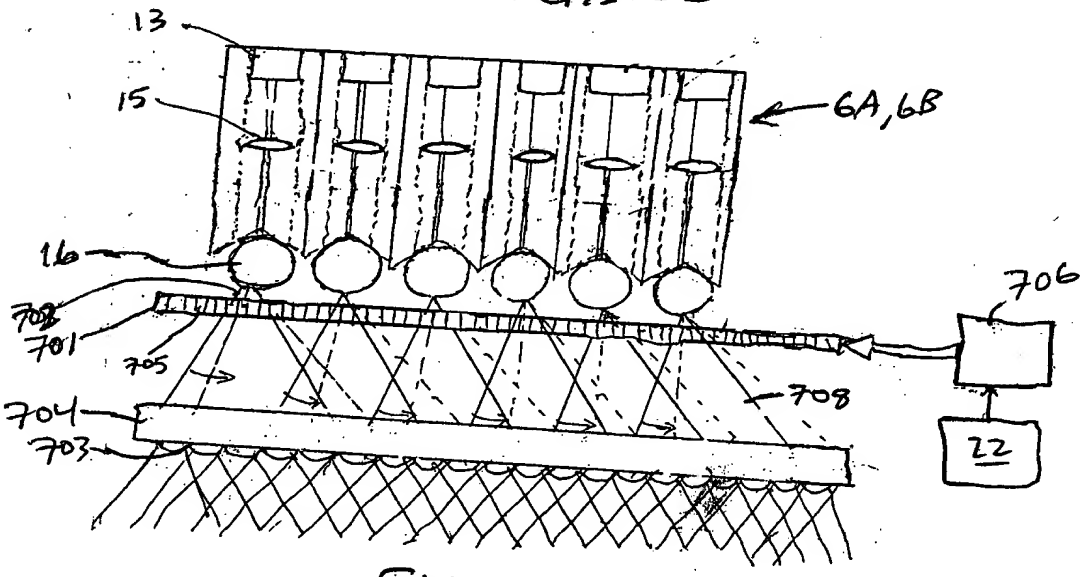


FIG.1IG

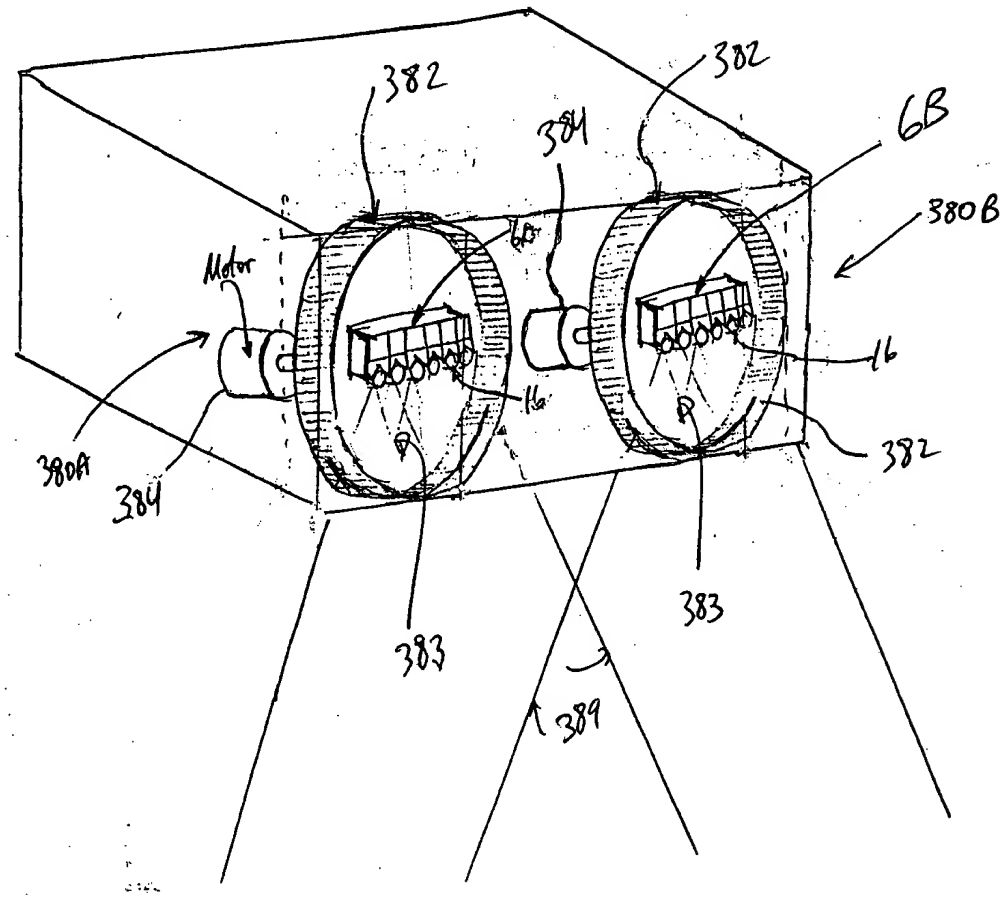


FIG. 1I 7A

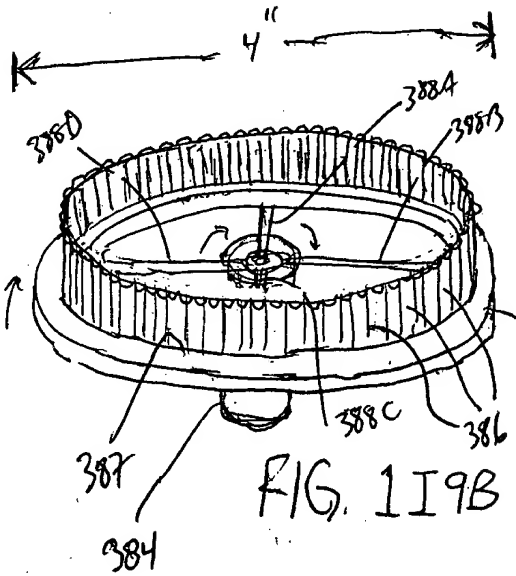


FIG. 1I9B

optical specifications:

- 30 cylindrical lens (lines) per linear inch
- focal length ≈ 2.0 millimeters
- diameter of lenticular carousel ≈ 4 inches
- acrylic material
- lenticular cylindrical elements on inside diameter

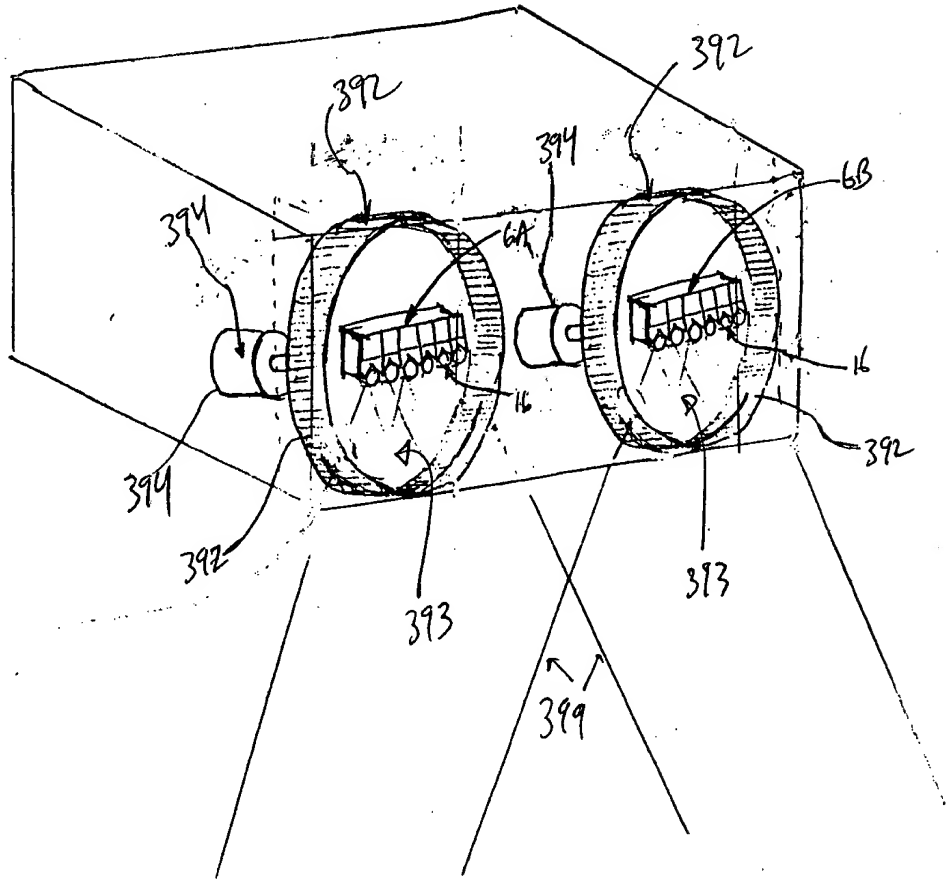


FIG. 1I 10A

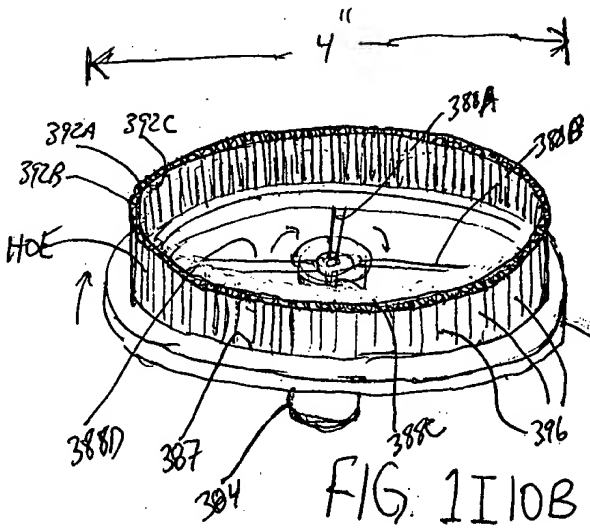


FIG. 11108

optical specifications:

- 30 cylindrical lens (lines) per linear inch
- focal length ≈ 2.0 millimeters
- diameter of lenticular carousel ≈ 4 inches
- acrylic material
  - lenticular cylindrical elements on inside diameter

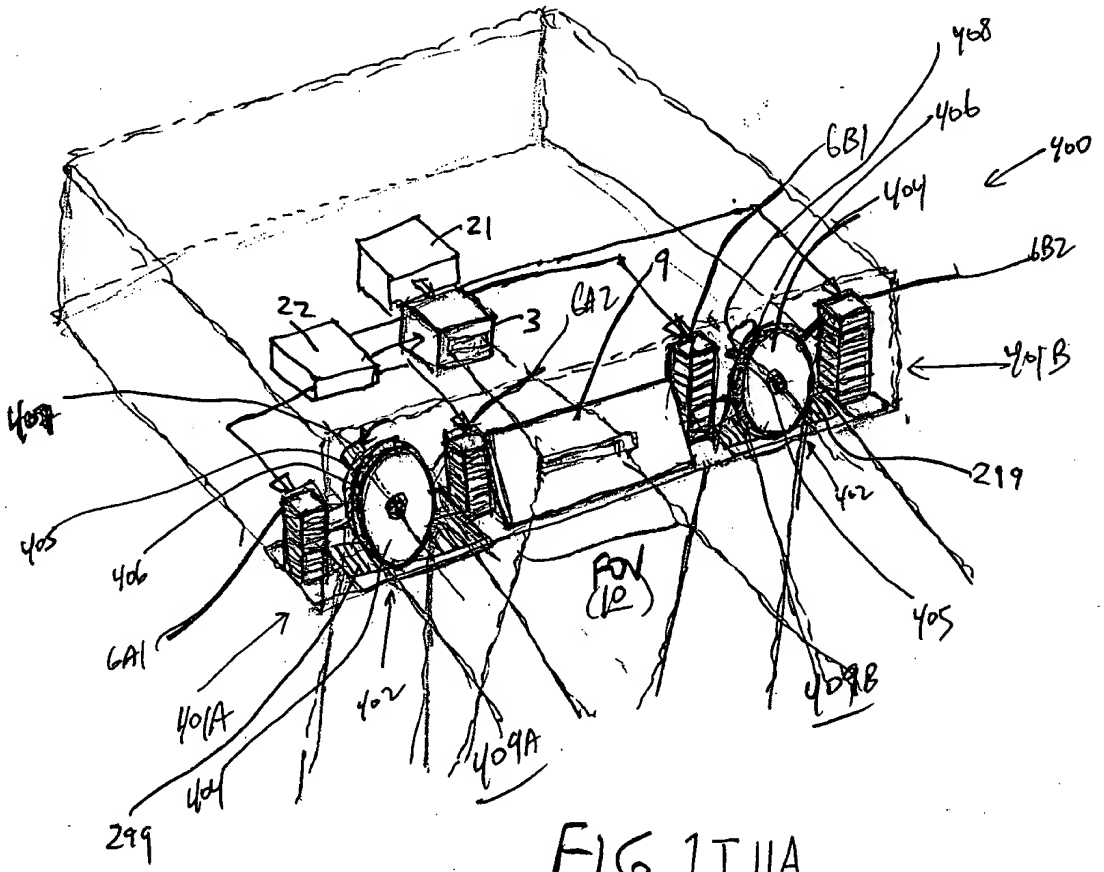


FIG. 1I11A

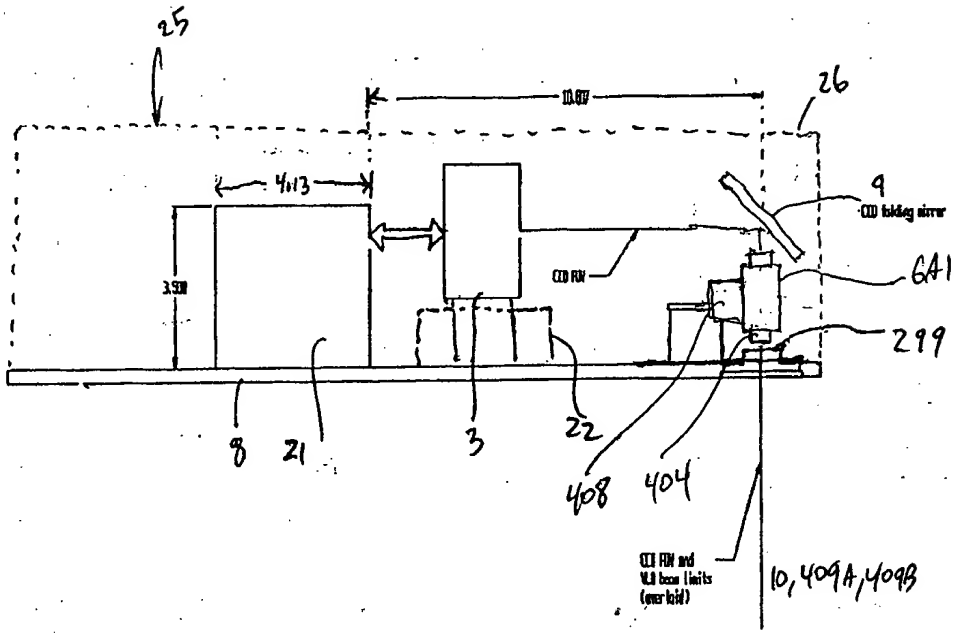

25
10.827
26
4.173
9
CCD folding mirror
3.528
CCD FPA
GA1
299
8
21
3
22
408
404
CCD FPA and VLA beam limits (over hold)
10, 409A, 409B

FIG 1I 11B

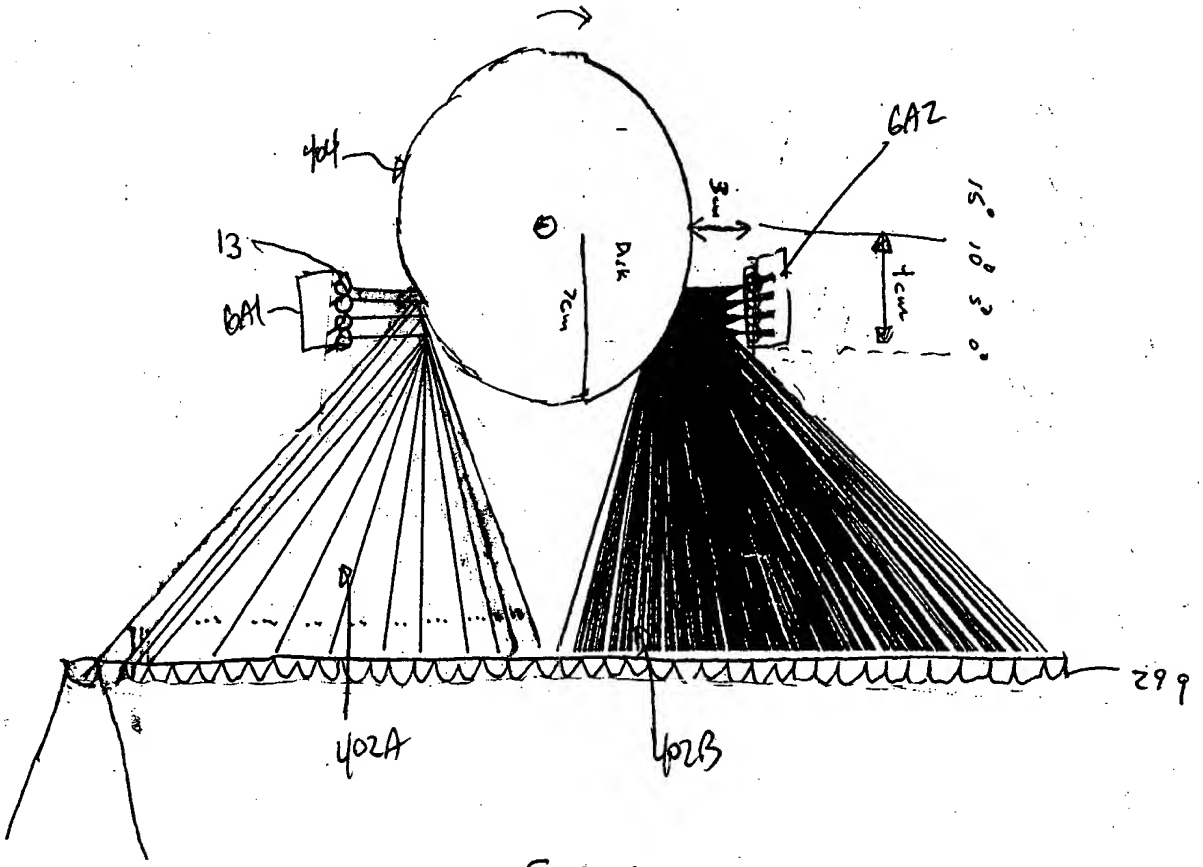


FIG. 1I11C

Second Generalized Method of Reducing Speckle-Noise Patterns at Image Detection Array of the IFD Subsystem (3)

(IPMF)

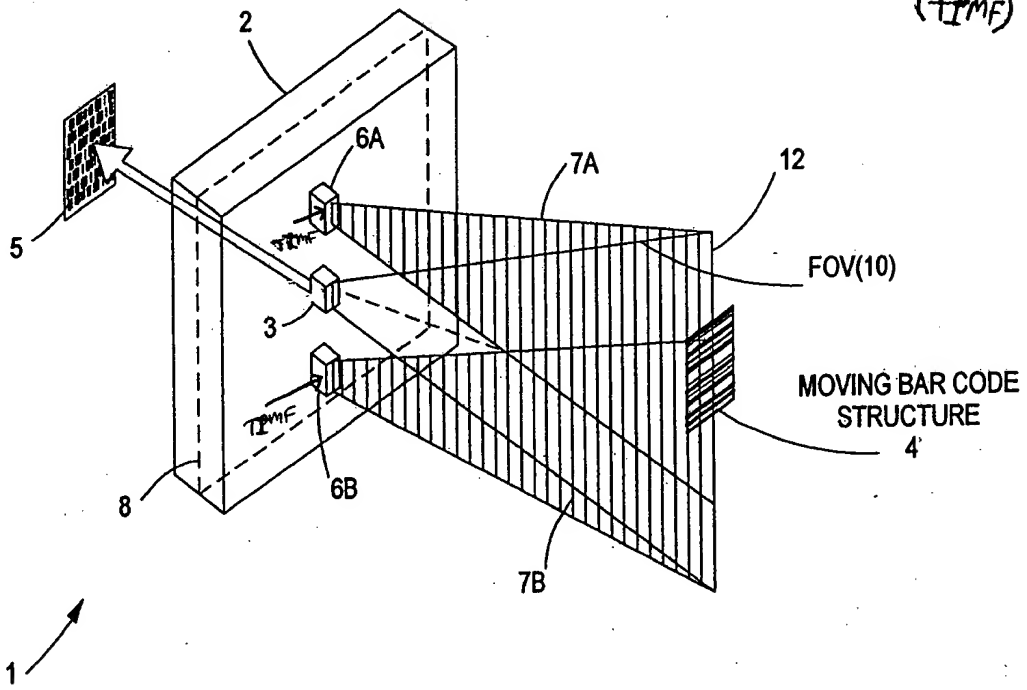


FIG. 1 I 12

39/206

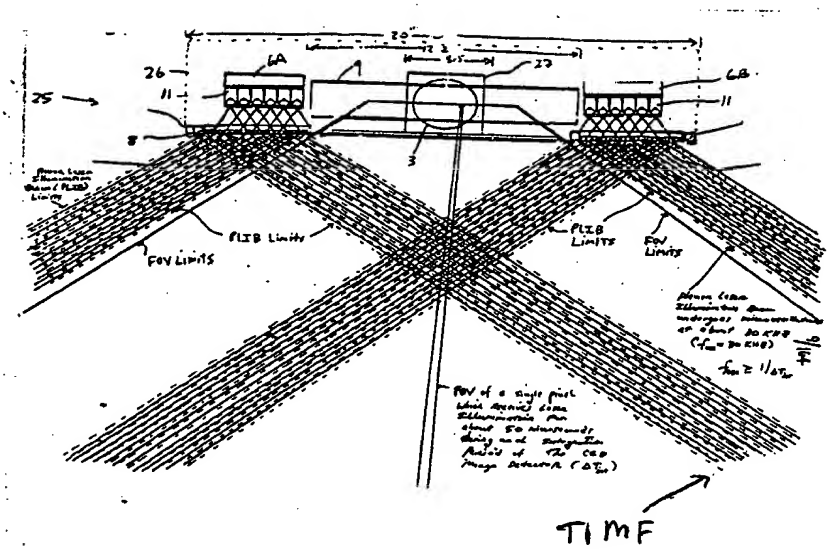


FIG. 1I 13A

The Second Generalized Speckle-Noise Pattern Reduction Method Of The Present Invention

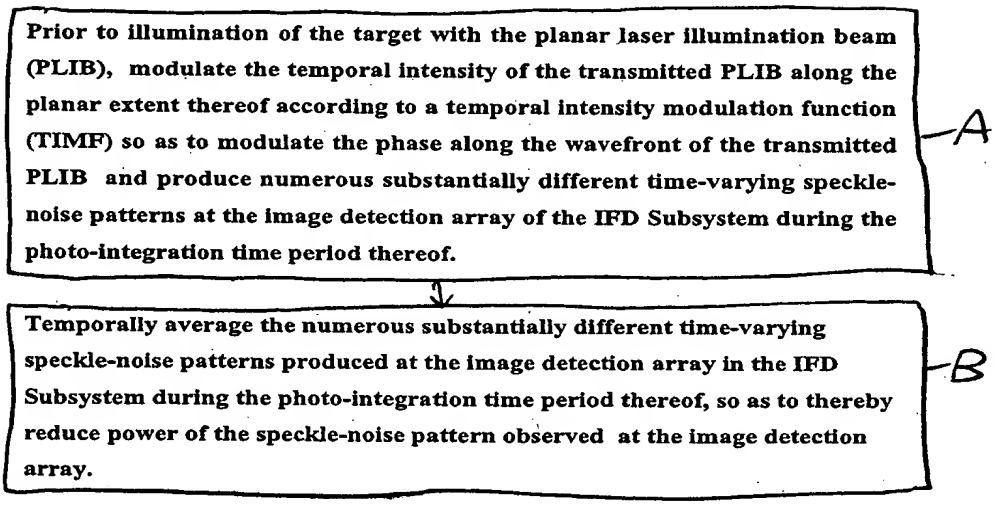


FIG. 1I13B

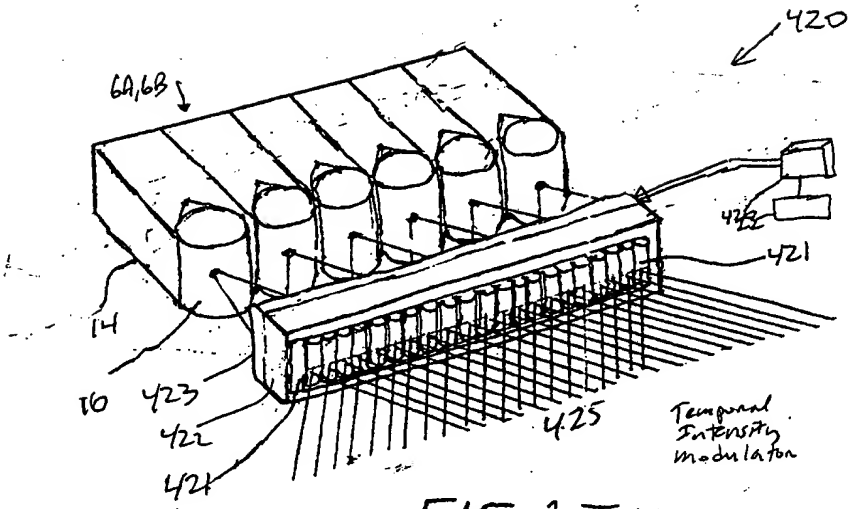


FIG. 1I14A

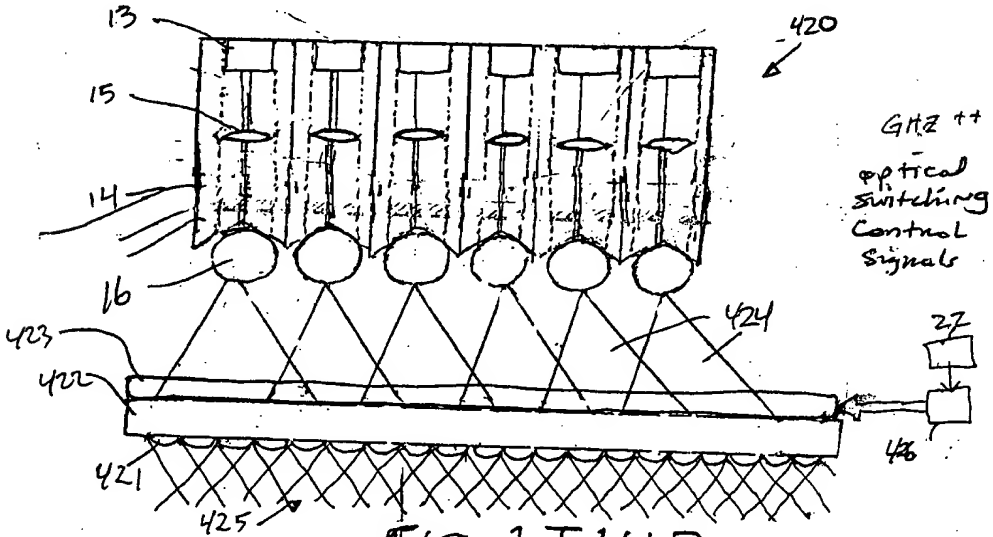


FIG. 1I14B

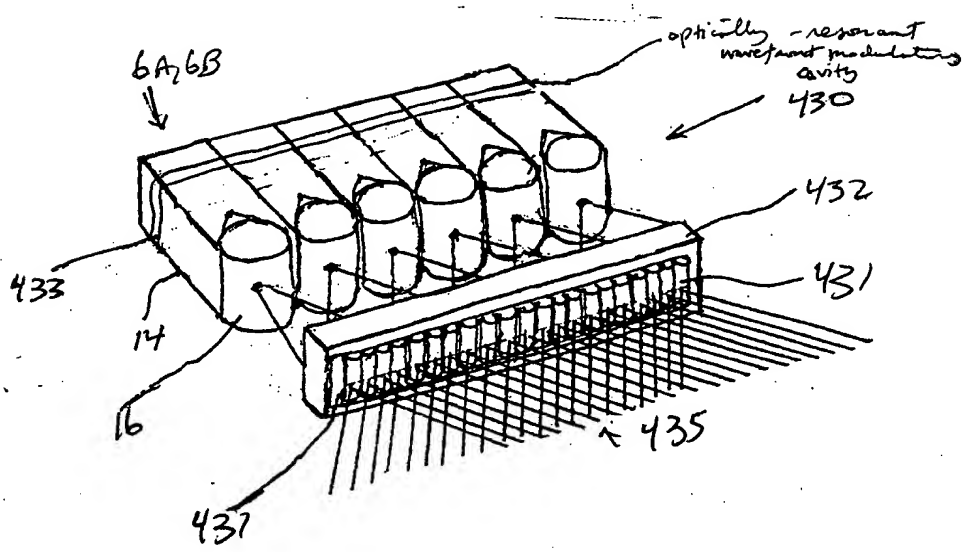


FIG. 1I15A

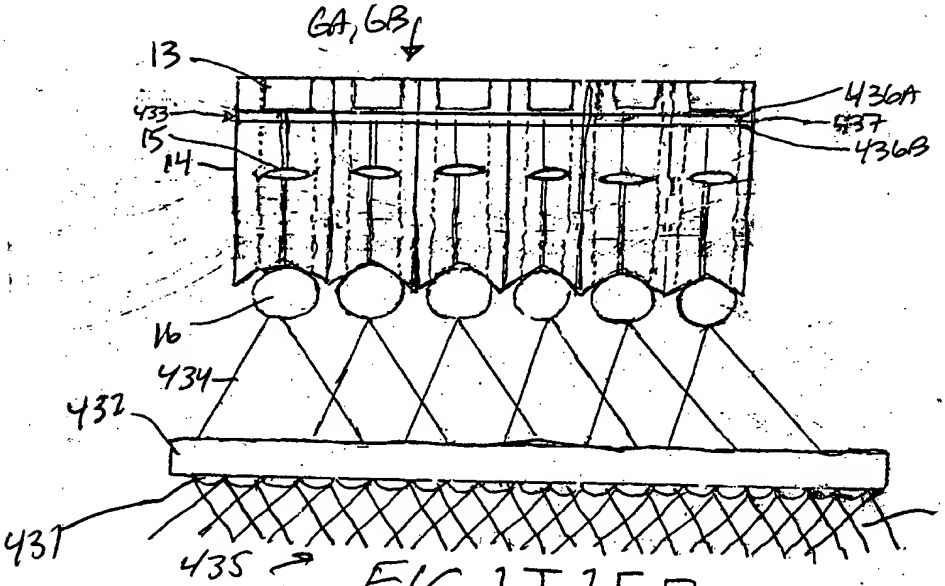


FIG. 1I15B

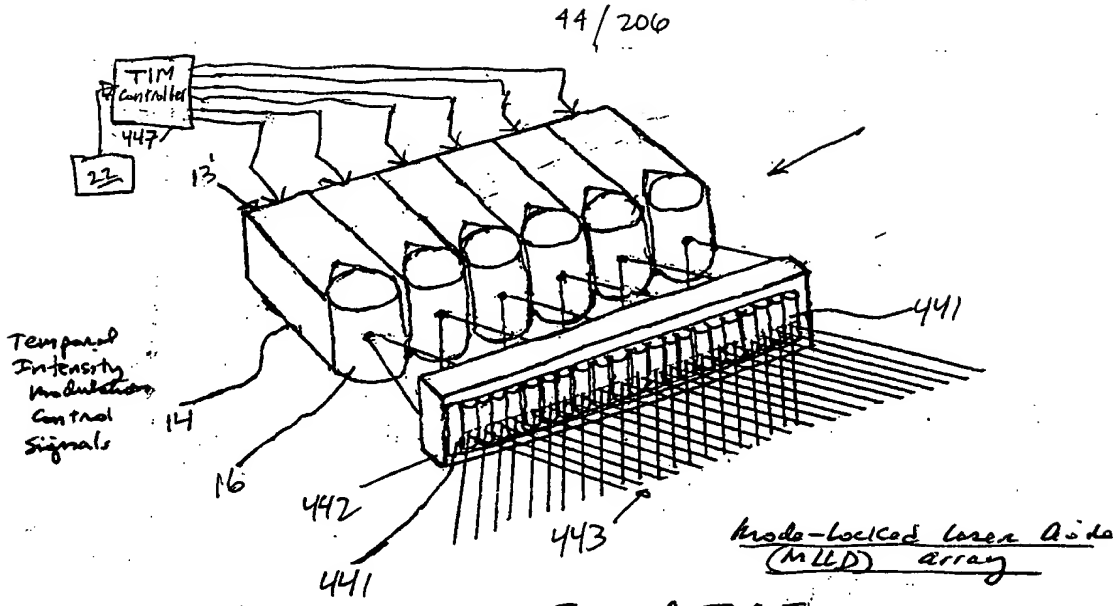


FIG. 1I15C

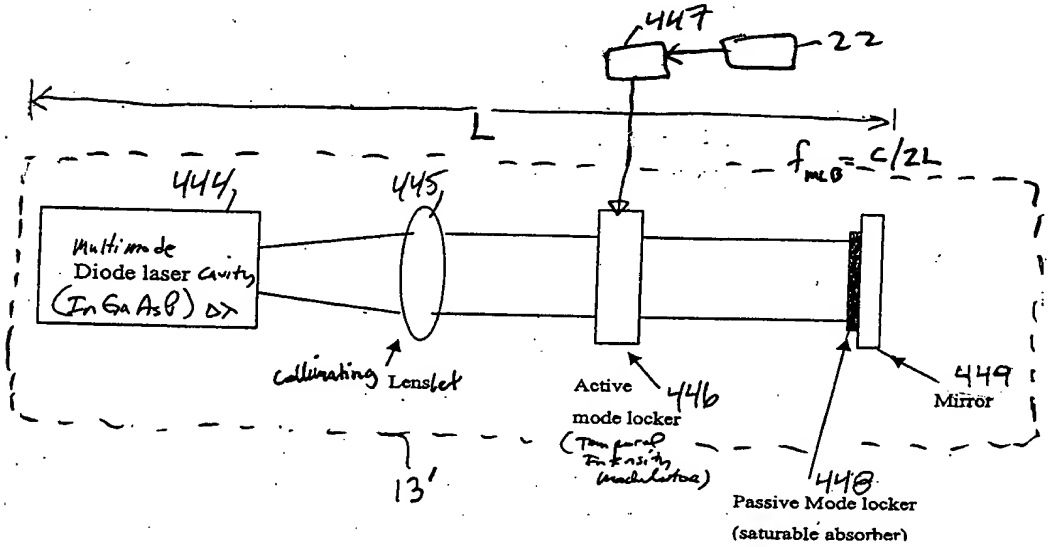


FIG. 1I15D

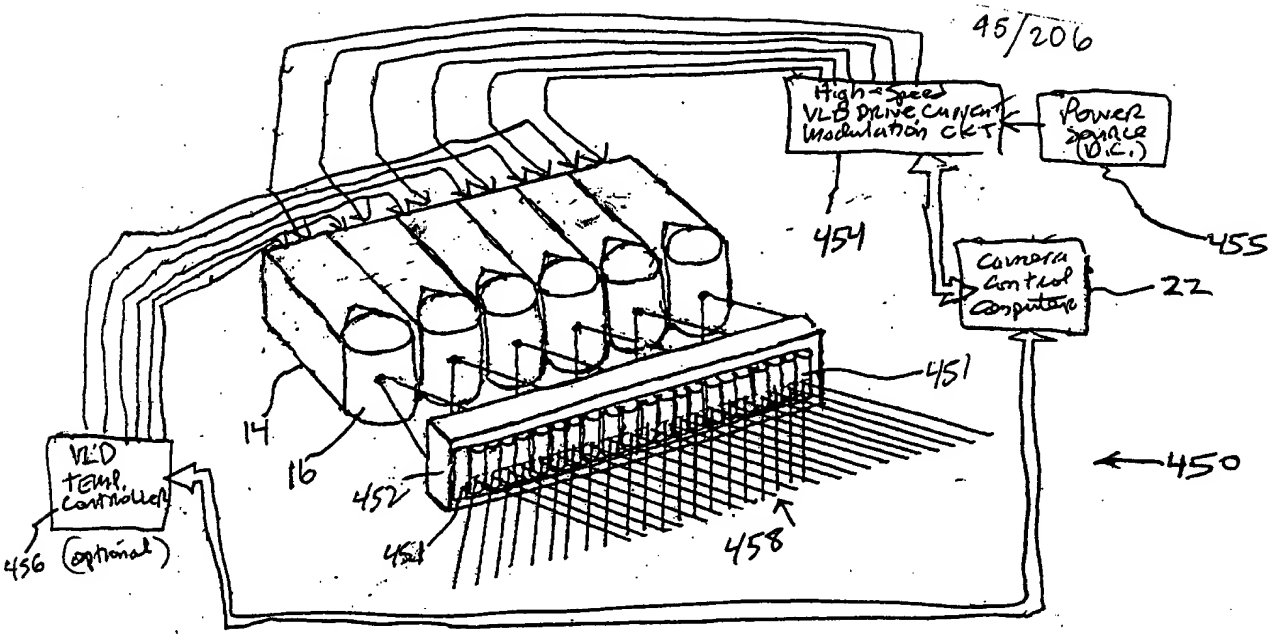


FIG. 1I16A

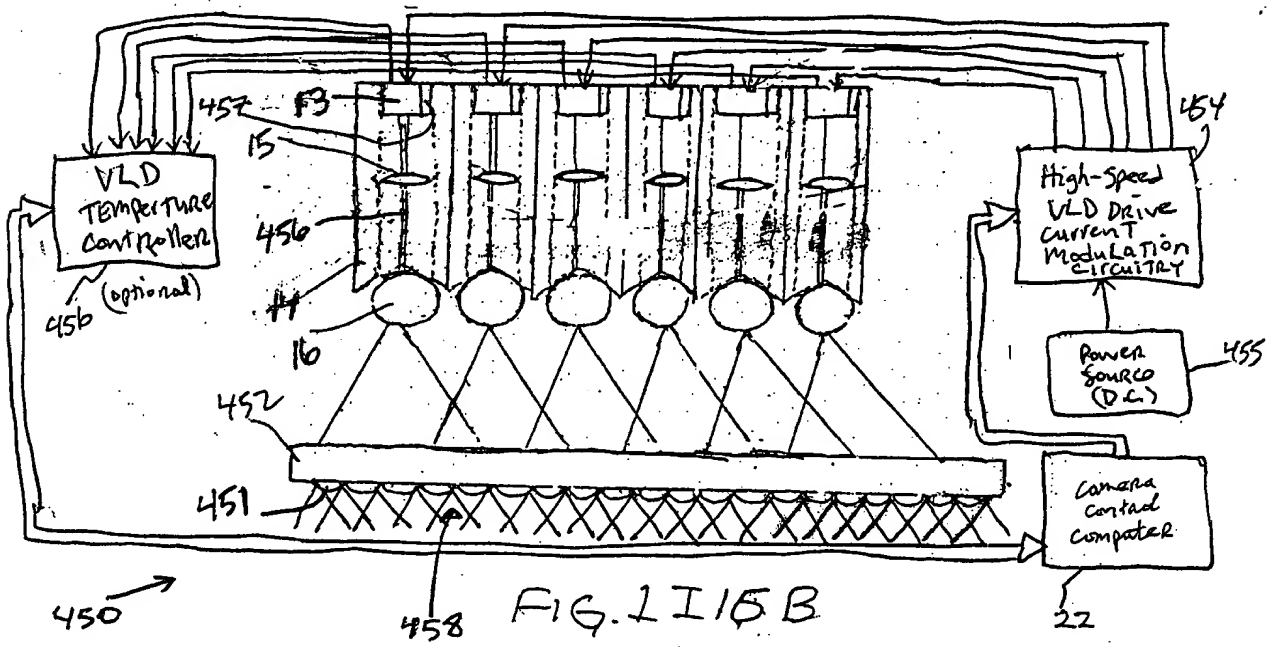


FIG. 1I16B

Third GENERALIZED METHOD of Reducing Speckle-Noise PATTERNS AT Image Detection array OF the IFD SubSystem (3)

(S'MF)

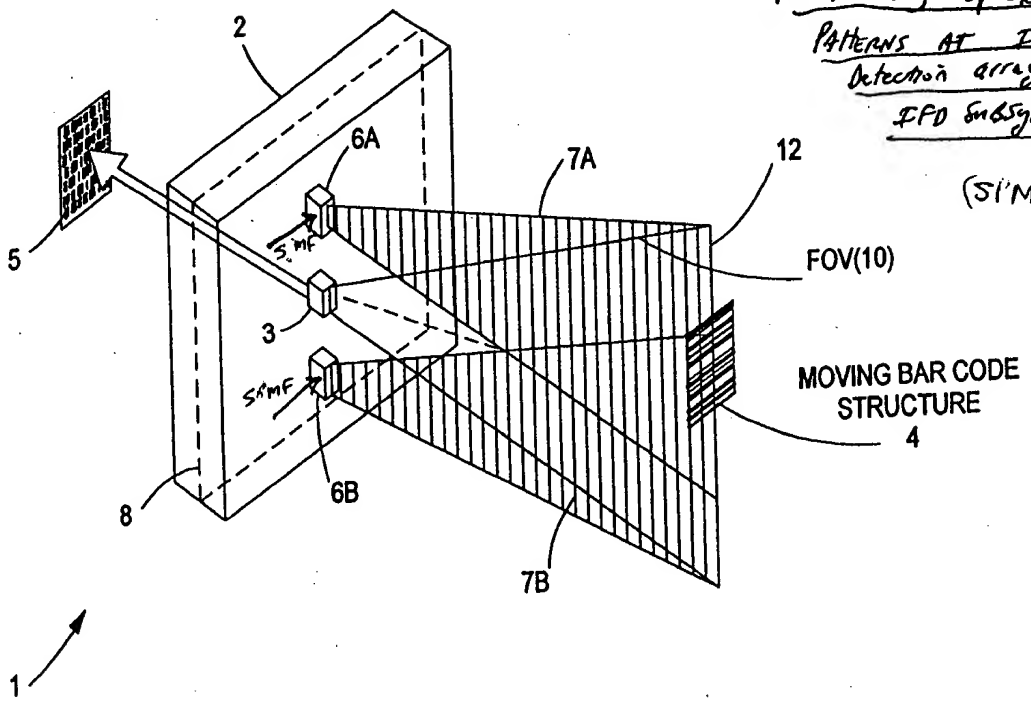
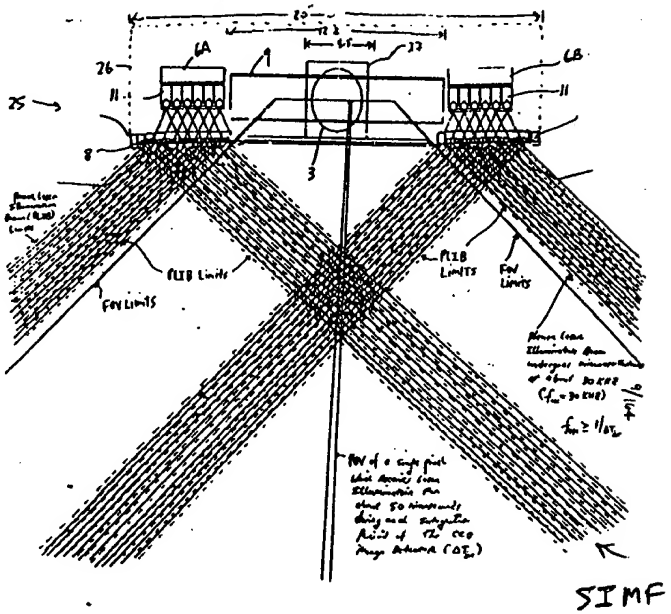


FIGURE 17



Prior to object Illumination

FIG. 1I 18A

The Third Generalized Speckle-Noise Pattern Reduction Method Of The Present Invention

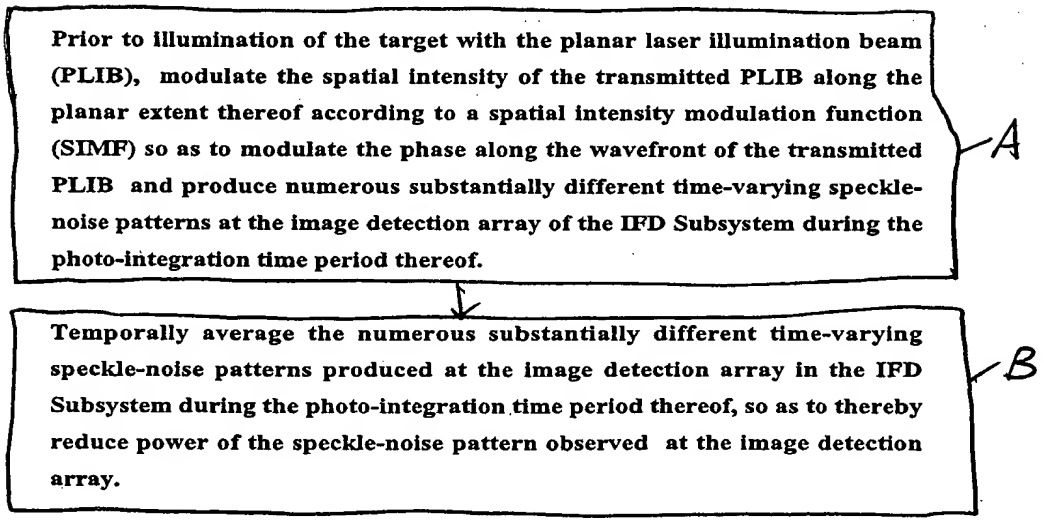


FIG. 1I18B

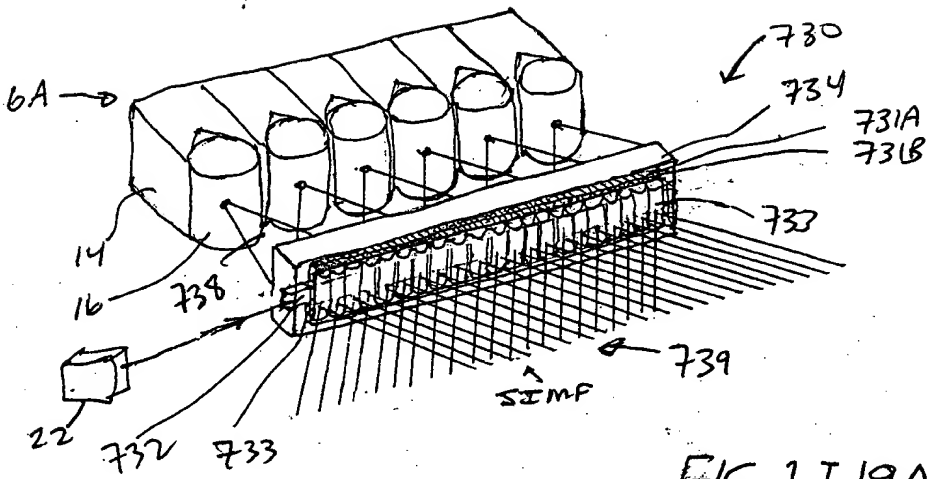


FIG. 1I19A

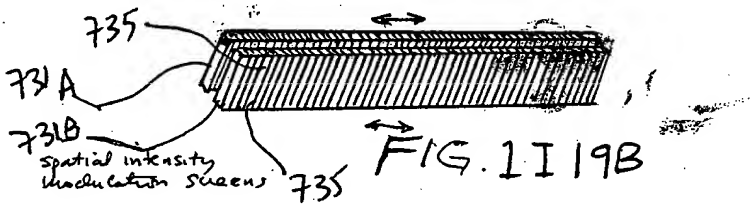


FIG. 1I19B

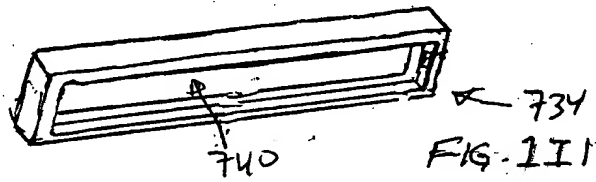


FIG. 1I19C

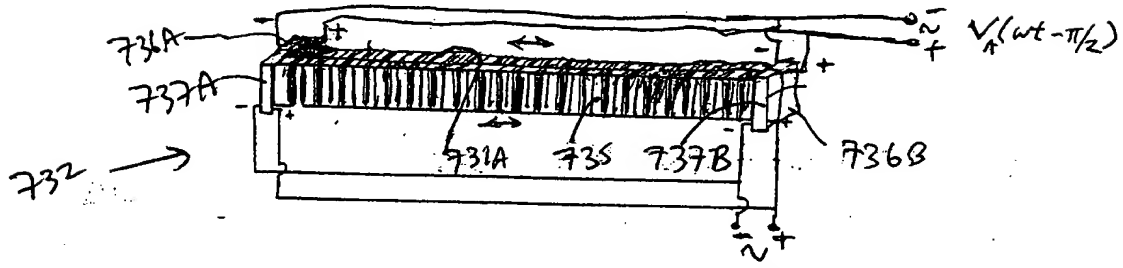


FIG. 1I19D

Fourth Generalized Method of Reducing Speckle-Noise Patterns at Image Detection Array of the IFD Subsystem

(SIMF)

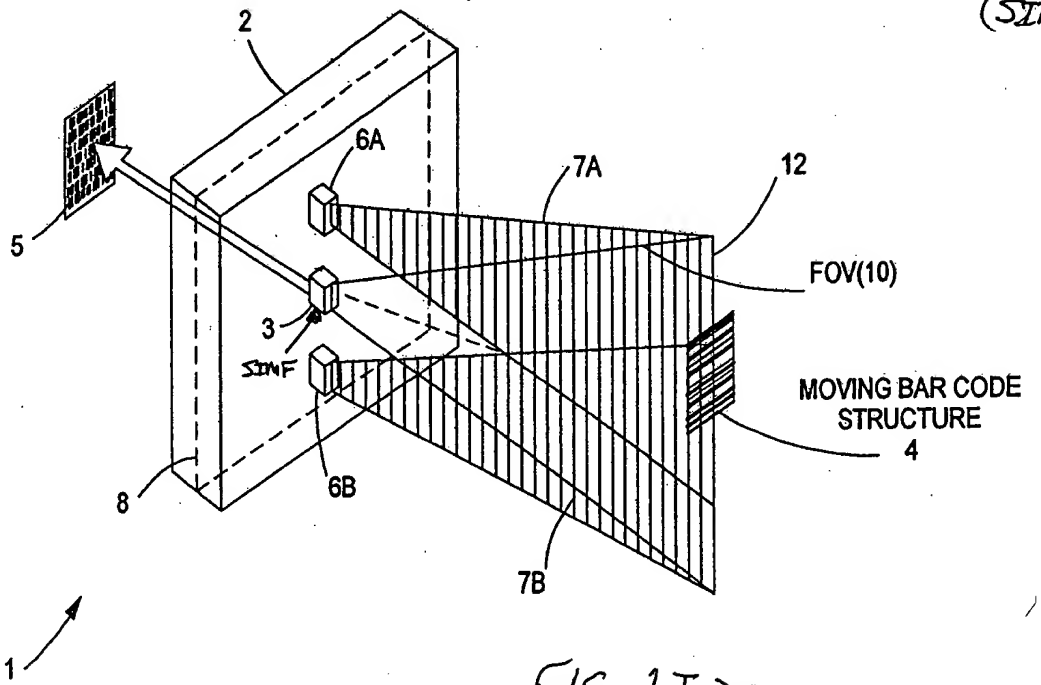


FIG. 11.20

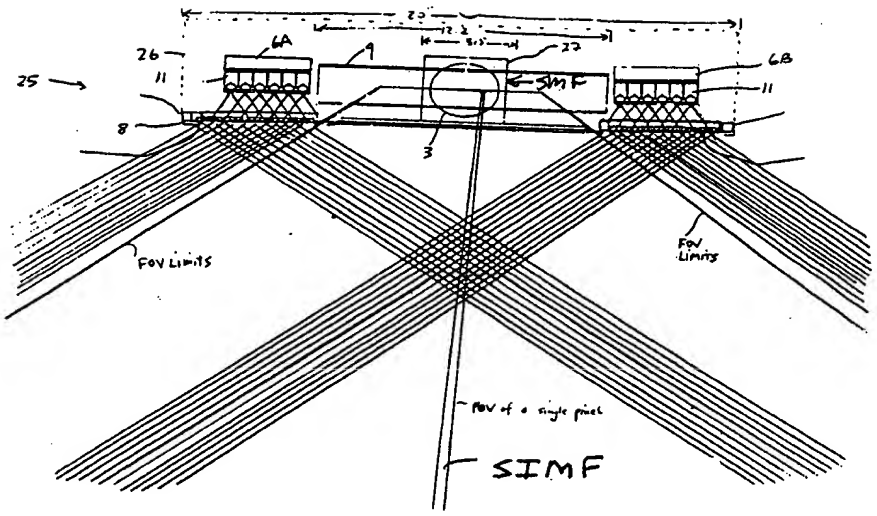

6A
6B
26
25
11
8
3
22
SIMF
FOV Limits
FOV Limits
FOV of a single pixel
SIMF

FIG. II 21A

The ~~Fourth~~ Generalized Speckle-Noise Pattern Reduction Method Of The Present Invention

After illumination of the target with the planar laser illumination beam (PLIB), modulate the spatial intensity of the reflected/scattered (i.e. received) PLIB along the planar extent thereof according to a spatial intensity modulation function (SIMF) so as to modulate the phase along the wavefront of the received PLIB and produce numerous substantially different time-varying speckle-noise patterns at the image detection array of the IFD Subsystem during the photo-integration time period thereof. — A

Temporally average the many substantially different time-varying speckle-noise patterns produced at the image detection array in the IFD Subsystem during the photo-integration time period thereof, so as to thereby reduce the speckle-noise pattern observed at the image detection array. — B

FIG. 11 21B

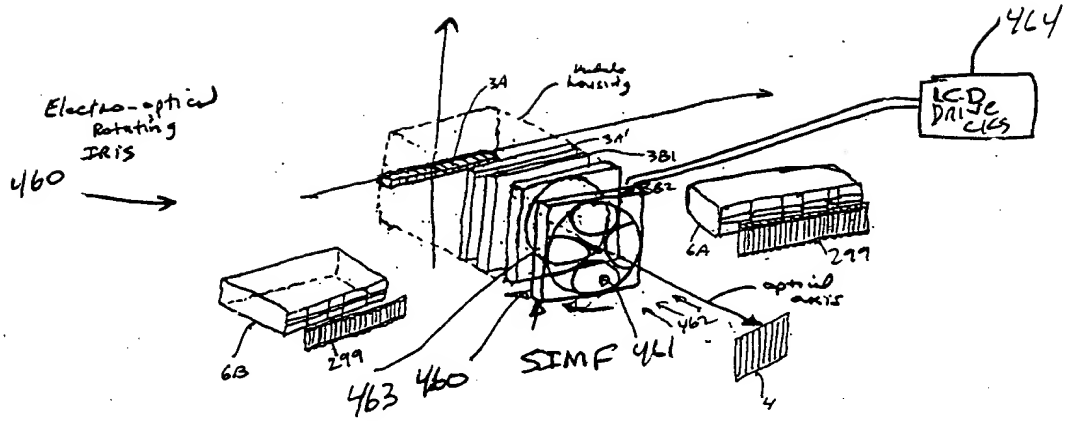


FIG. 11 22A

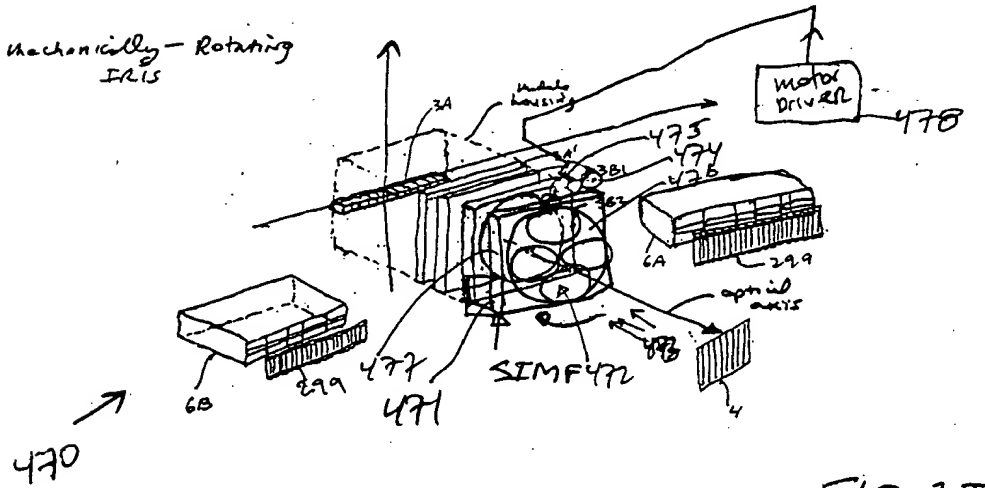


FIG. 11 22B

Fourth Generalized Method of Reducing Speckle-Noise Patterns at Image Detection Array of the IFD Subsystem

(TIMF)

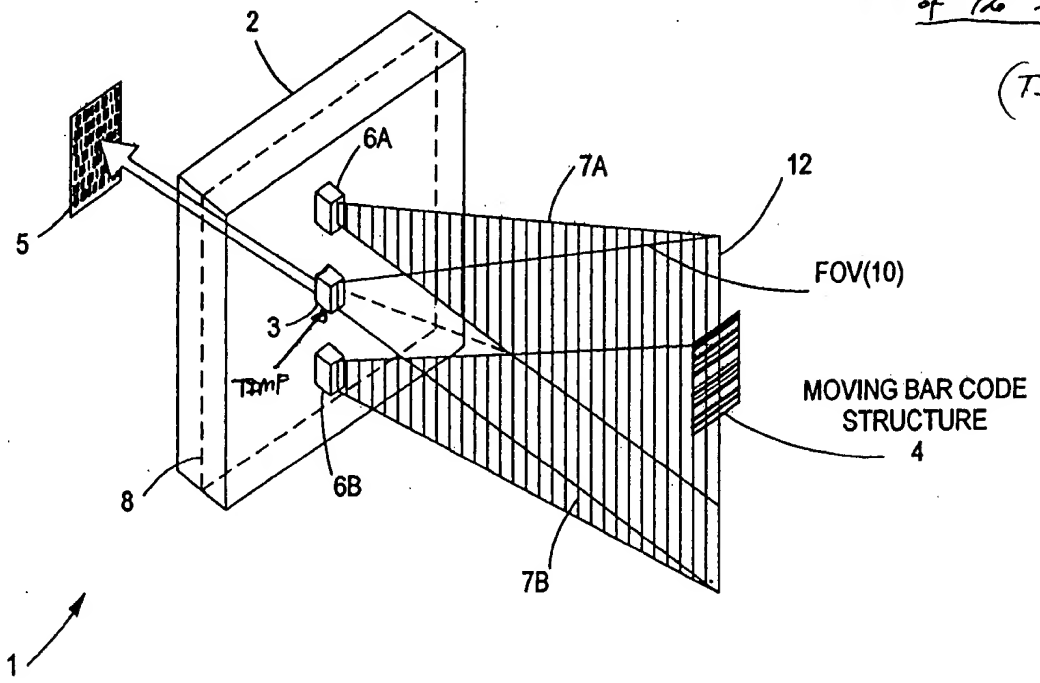


FIG. 1I23

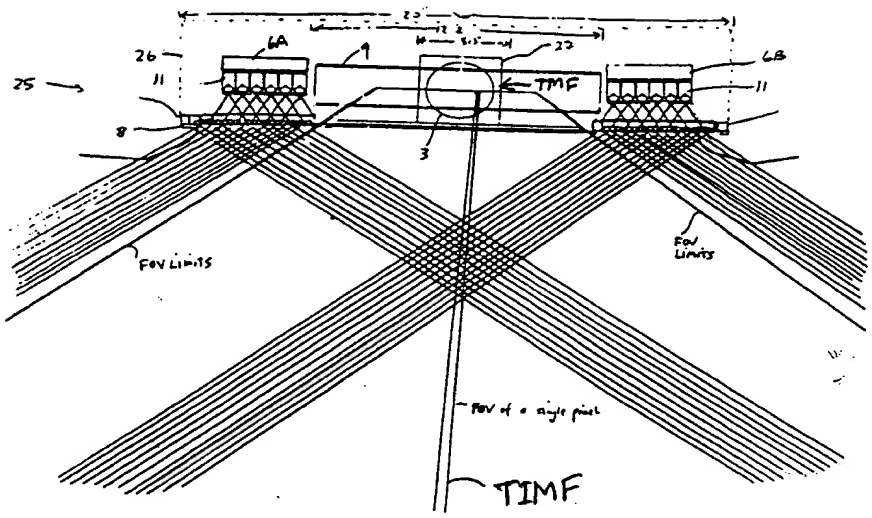

25
26
11
6A
6B
TMF
22
8
3
FOV LIMITS
FOV LIMITS
FOV of a single pixel
TIMF

FIG. 1I 24A

The Fifth Generalized Speckle-Noise Pattern Reduction Method Of The Present Invention

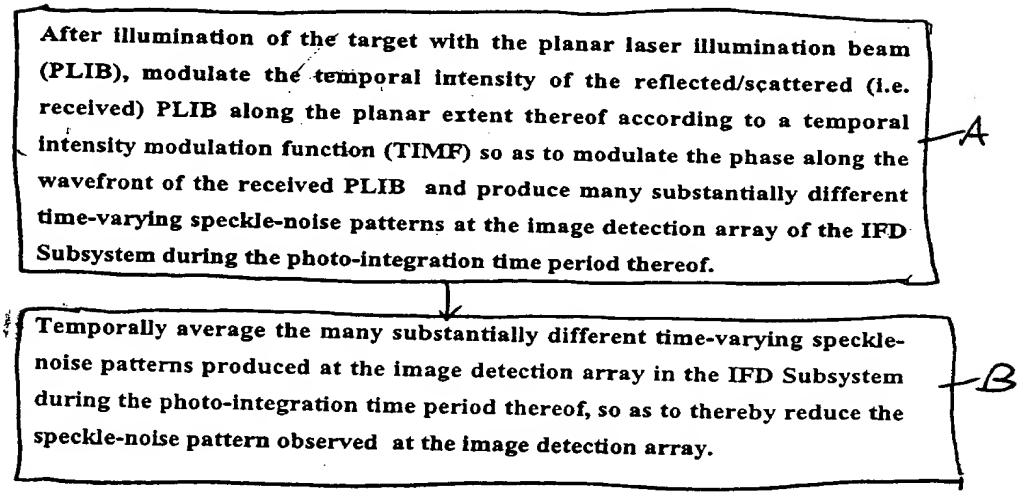


FIG. 11 24B

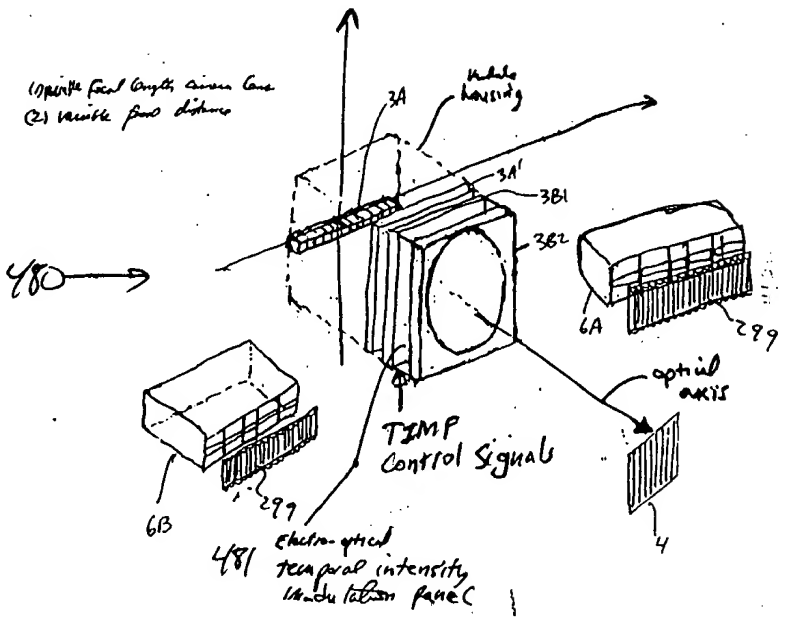

(2) variable focal length zoom lens
(2) variable focal distance
3A
variable housing
3A'
3B1
3B2
480
6A
299
optical axis
TIMP
Control Signals
6B
299
481
electro-optical
temporal intensity
modulation panel
4

FIG. 11 25

Fixed focal Length lens cases

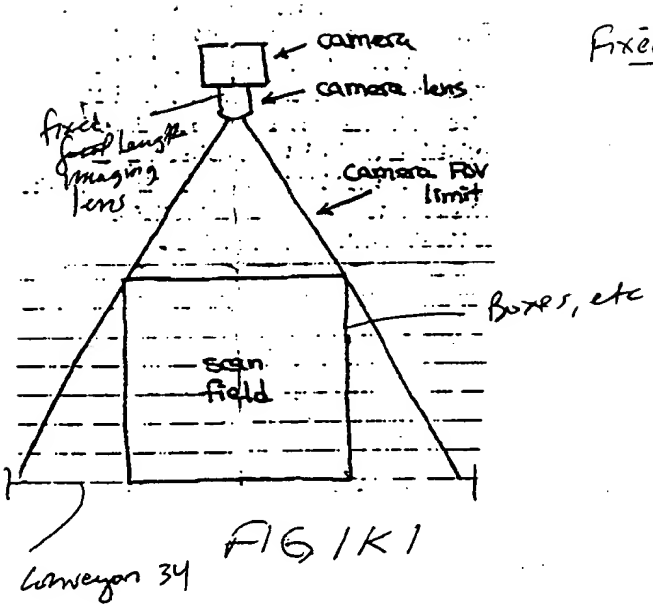


FIG 1K1

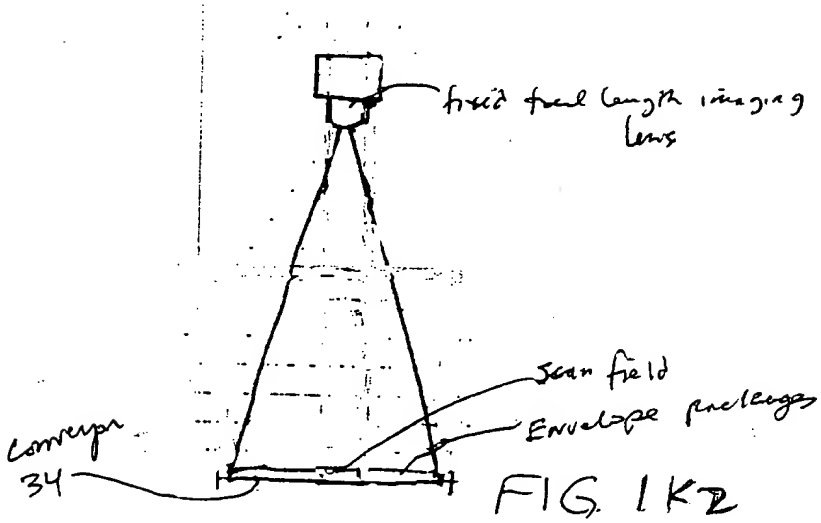


FIG. 1K2

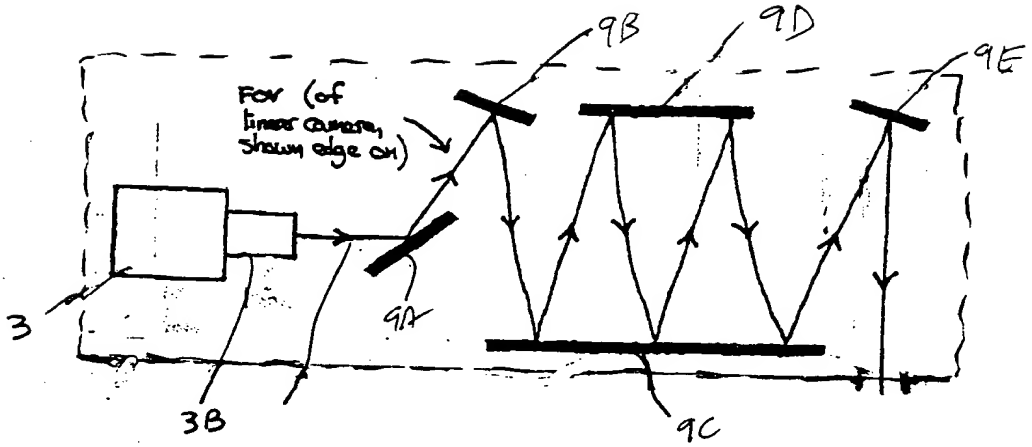


FIG. 1L1

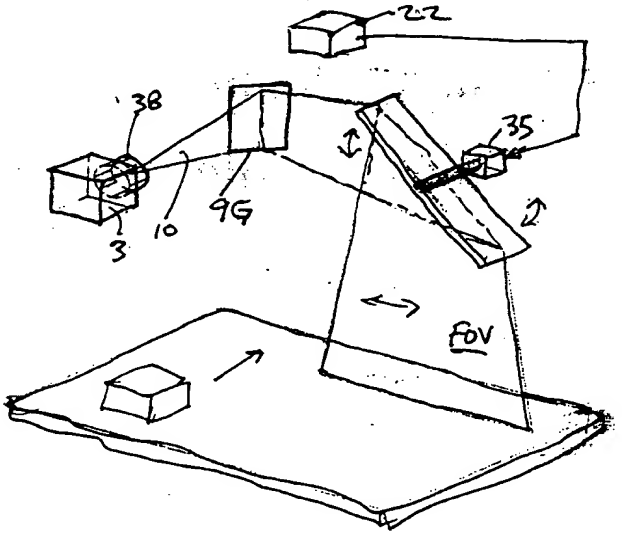


FIG 1L2

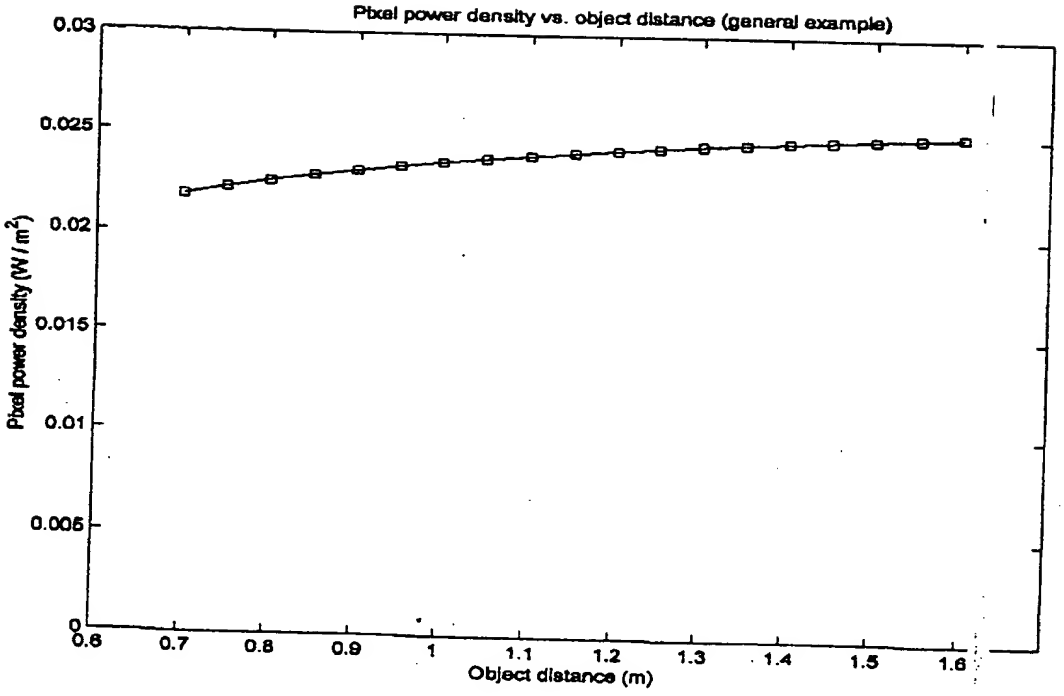

Pixel power density vs. object distance (general example)
Pixel power density (W / m²)
0.03
0.025
0.02
0.015
0.01
0.005
0
0.6
0.7
0.8
0.9
1
1.1
1.2
1.3
1.4
1.5
1.6
Object distance (m)

FIG. 1M1

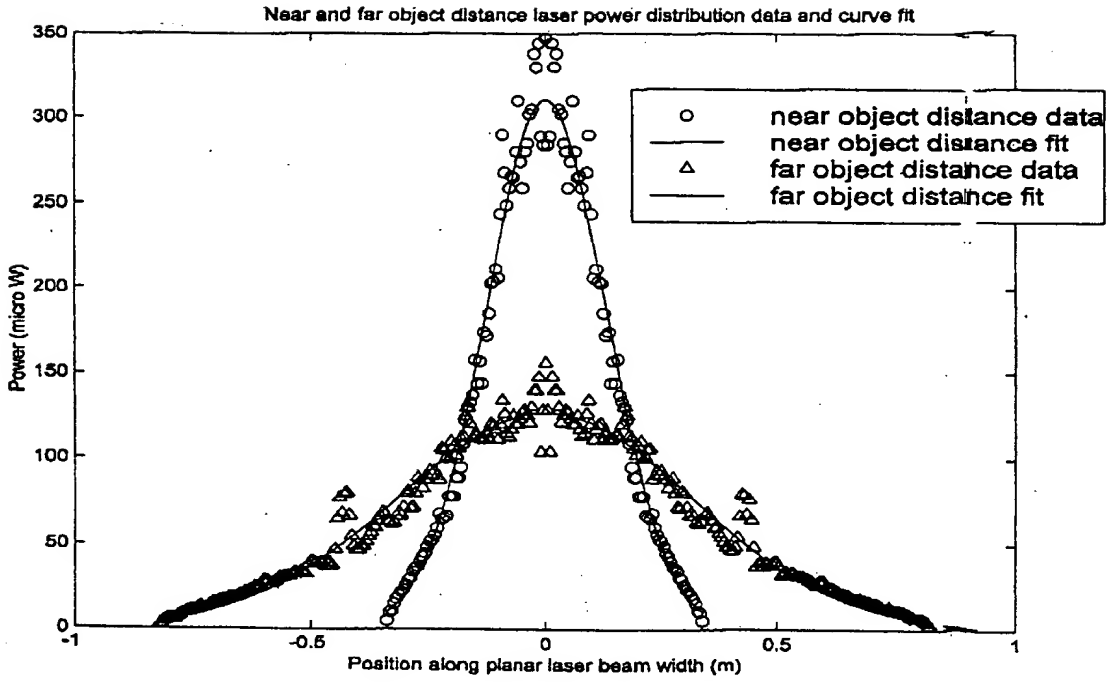

Near and far object distance laser power distribution data and curve fit
Power (micro W)
Position along planar laser beam width (m)
near object distance data
near object distance fit
far object distance data
far object distance fit
350
300
250
200
150
100
50
0
-1
-0.5
0
0.5
1

FIG. 1M2

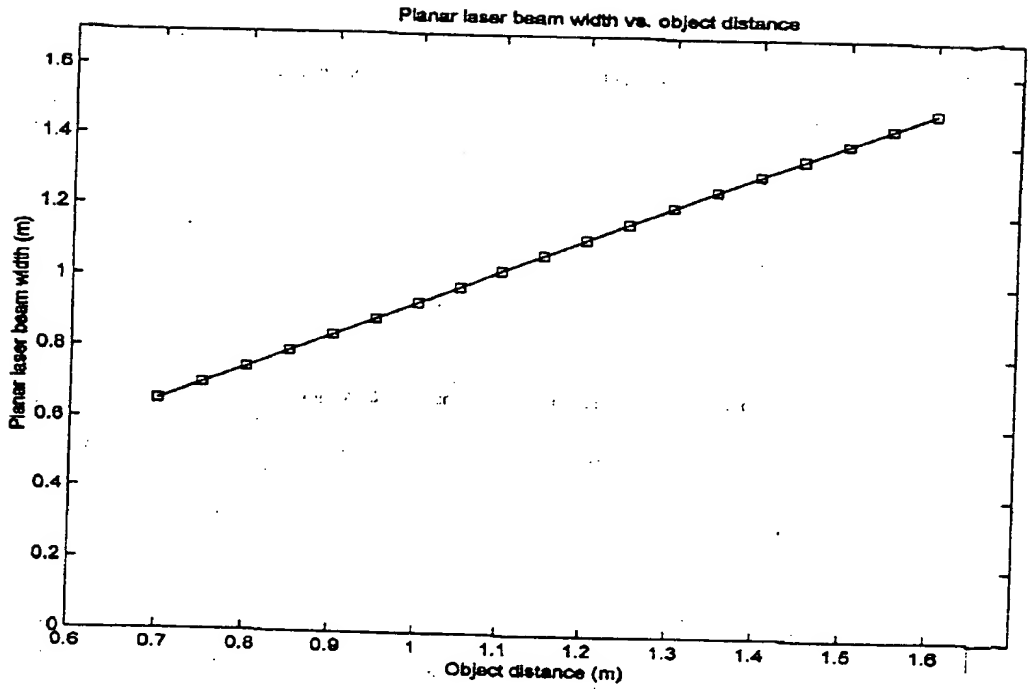

Planar laser beam width vs. object distance
Planar laser beam width (m)
Object distance (m)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
0.6
0.7
0.8
0.9
1
1.1
1.2
1.3
1.4
1.5
1.6

FIG. 1M3

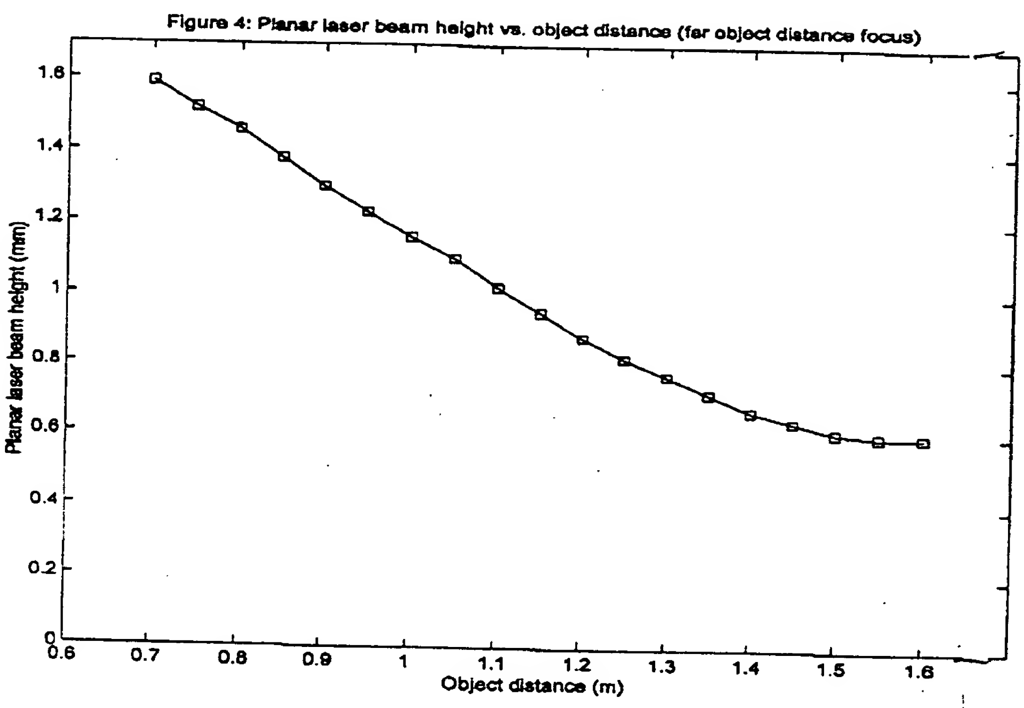


FIG 1M4

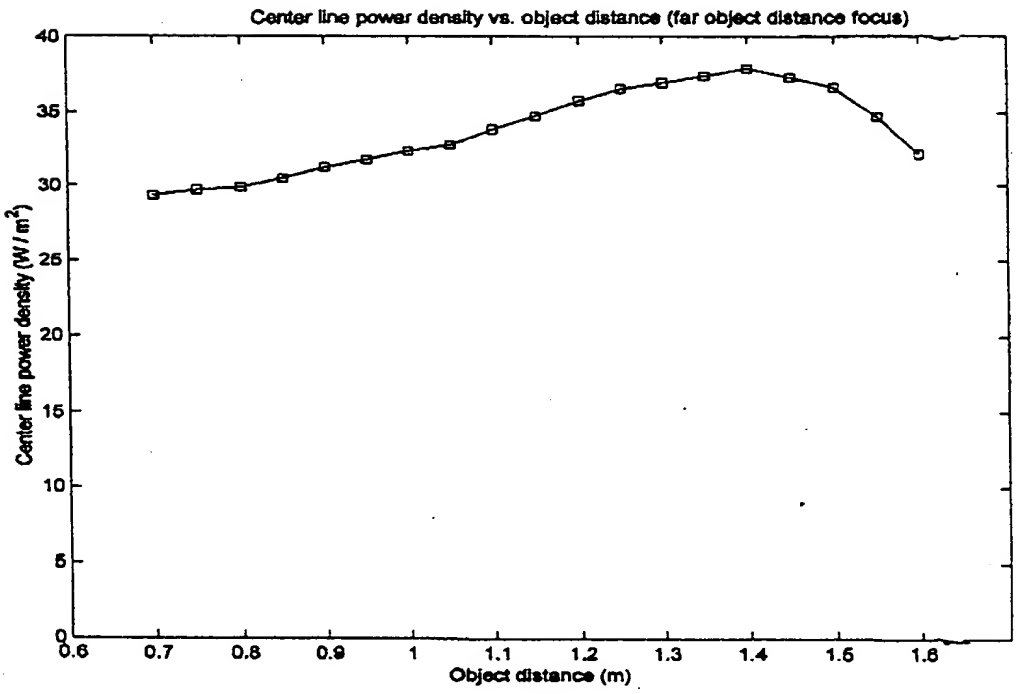

Center line power density vs. object distance (far object distance focus)
Center line power density (W / m2)
Object distance (m)
0
5
10
15
20
25
30
35
40
0.6
0.7
0.8
0.9
1
1.1
1.2
1.3
1.4
1.5
1.6

FIG. 1N

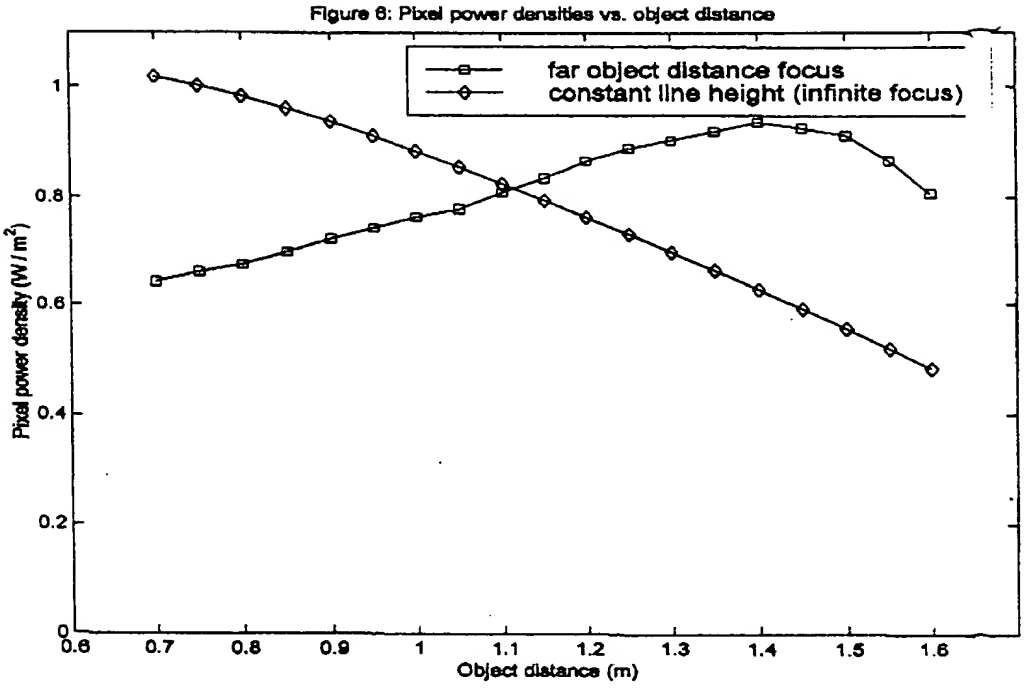


Figure 6: Pixel power densities vs. object distance
far object distance focus
constant line height (infinite focus)
Pixel power density (W / m²)
Object distance (m)
0
0.2
0.4
0.6
0.8
1
0.6
0.7
0.8
0.9
1
1.1
1.2
1.3
1.4
1.5
1.6

FIG. 10

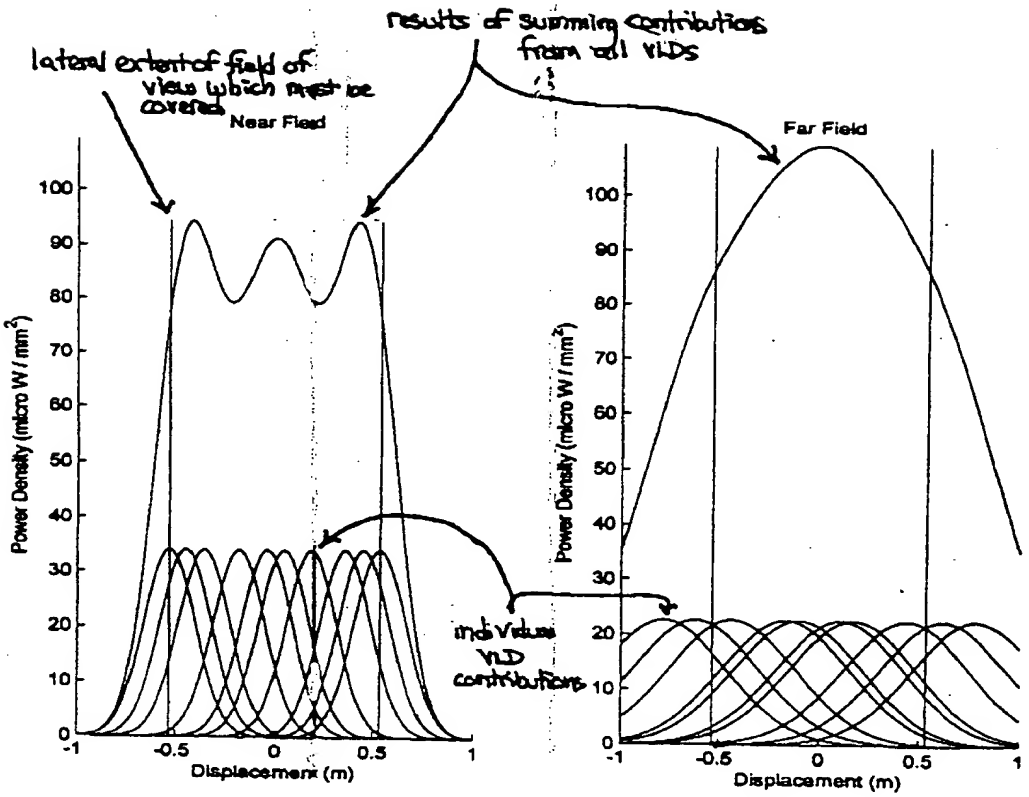


FIG 1P1

FIG 1P2

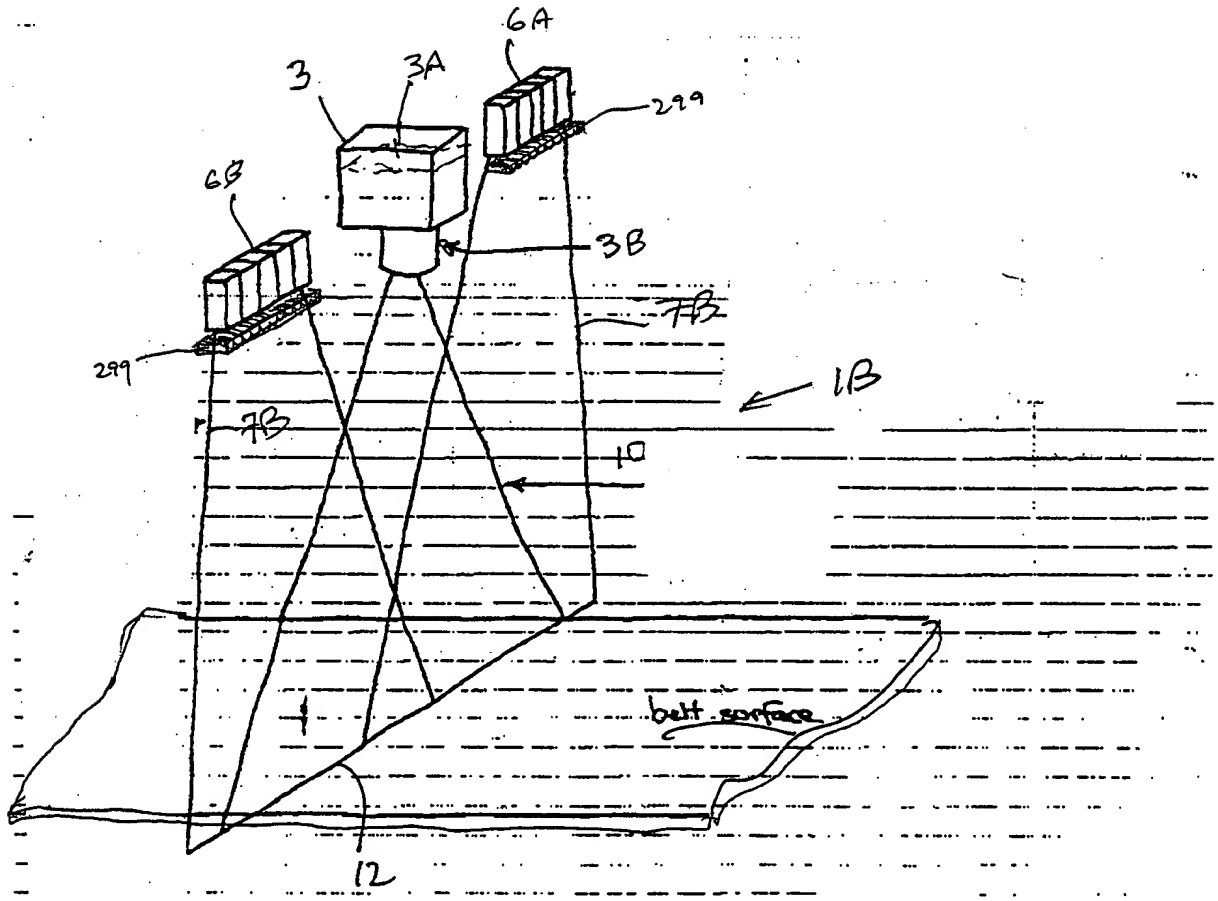


FIG. 1Q1

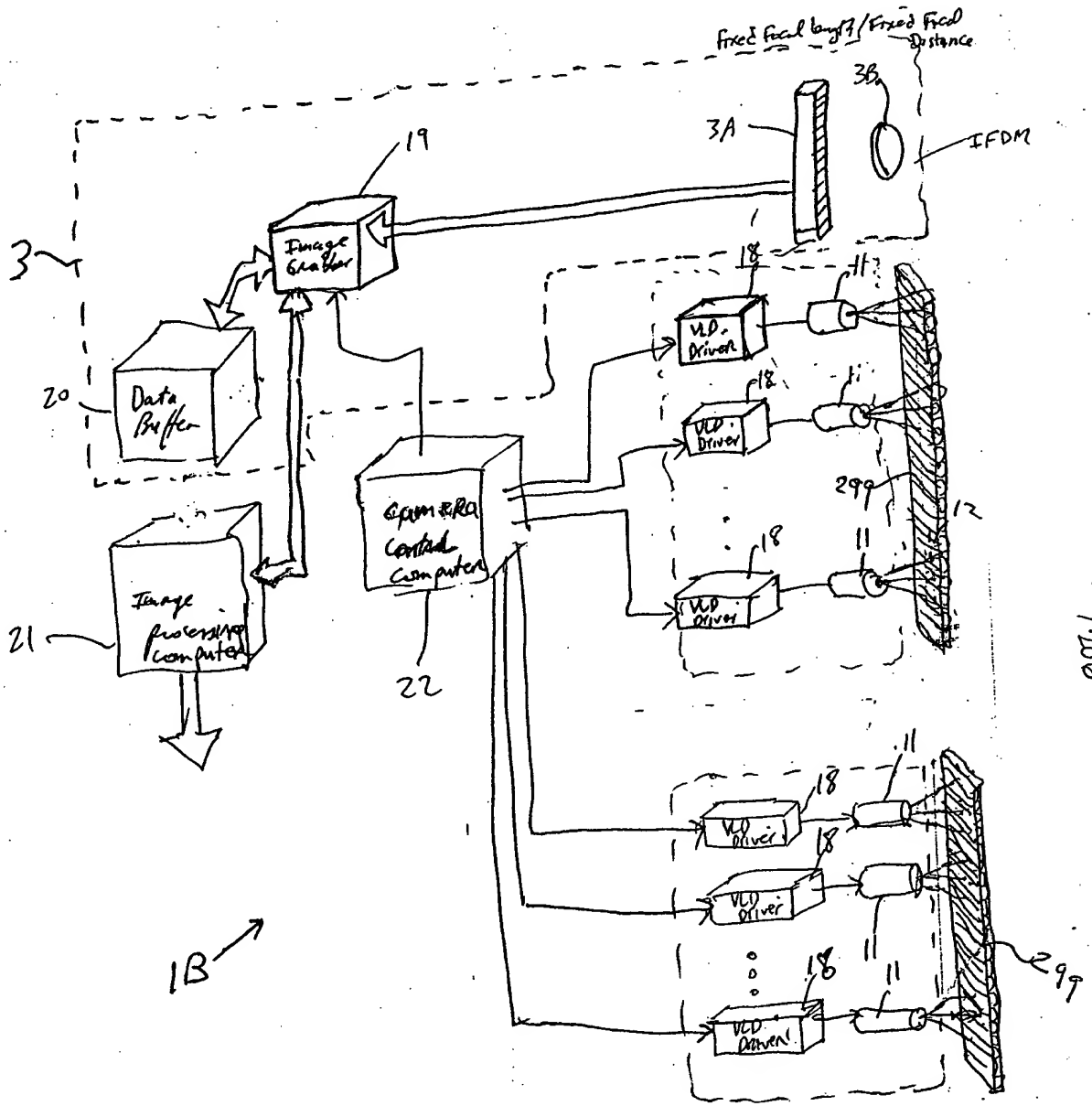

Fixed Focal length/Fixed Focal Distance
3B
3A
IFDM
19
Image Grabber
3
18
11
VLD Driver
20
Data Buffer
299
12
Camera & Robot Control Computer
Image Processing Computer
21
22
1B

FIG. 1Q2

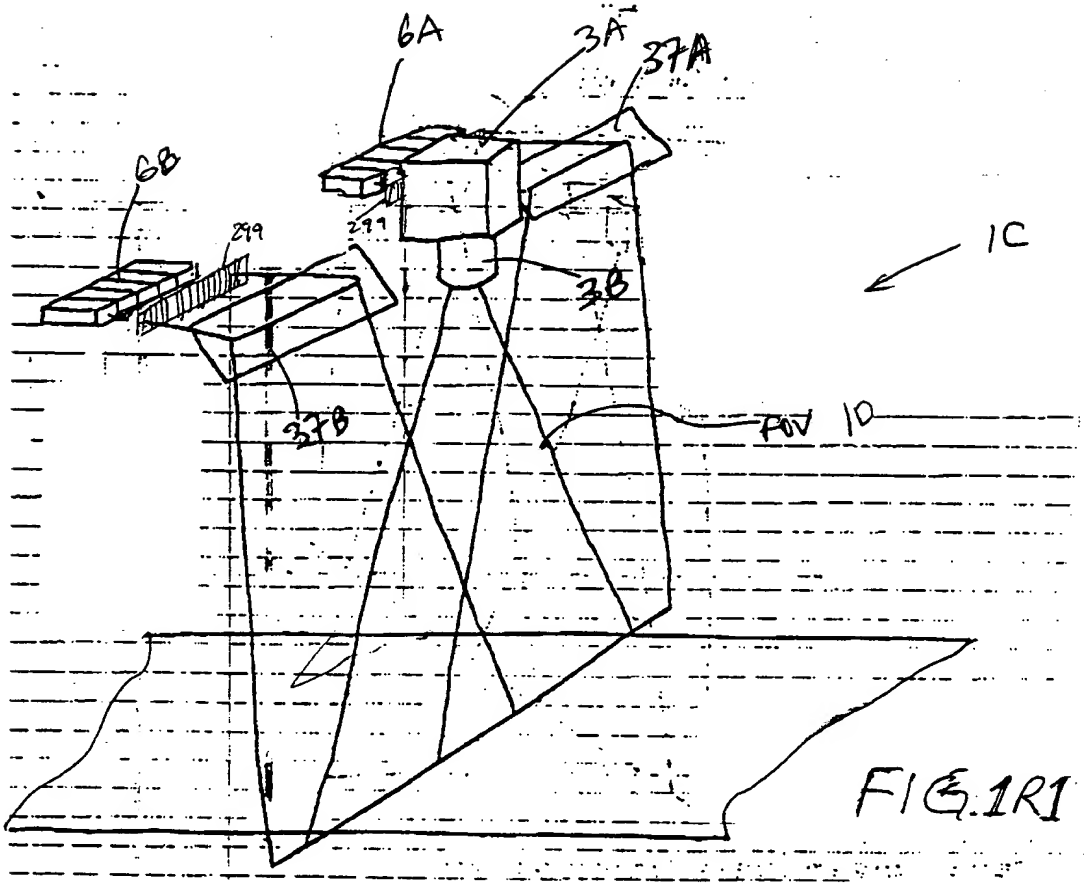


FIG.1R1

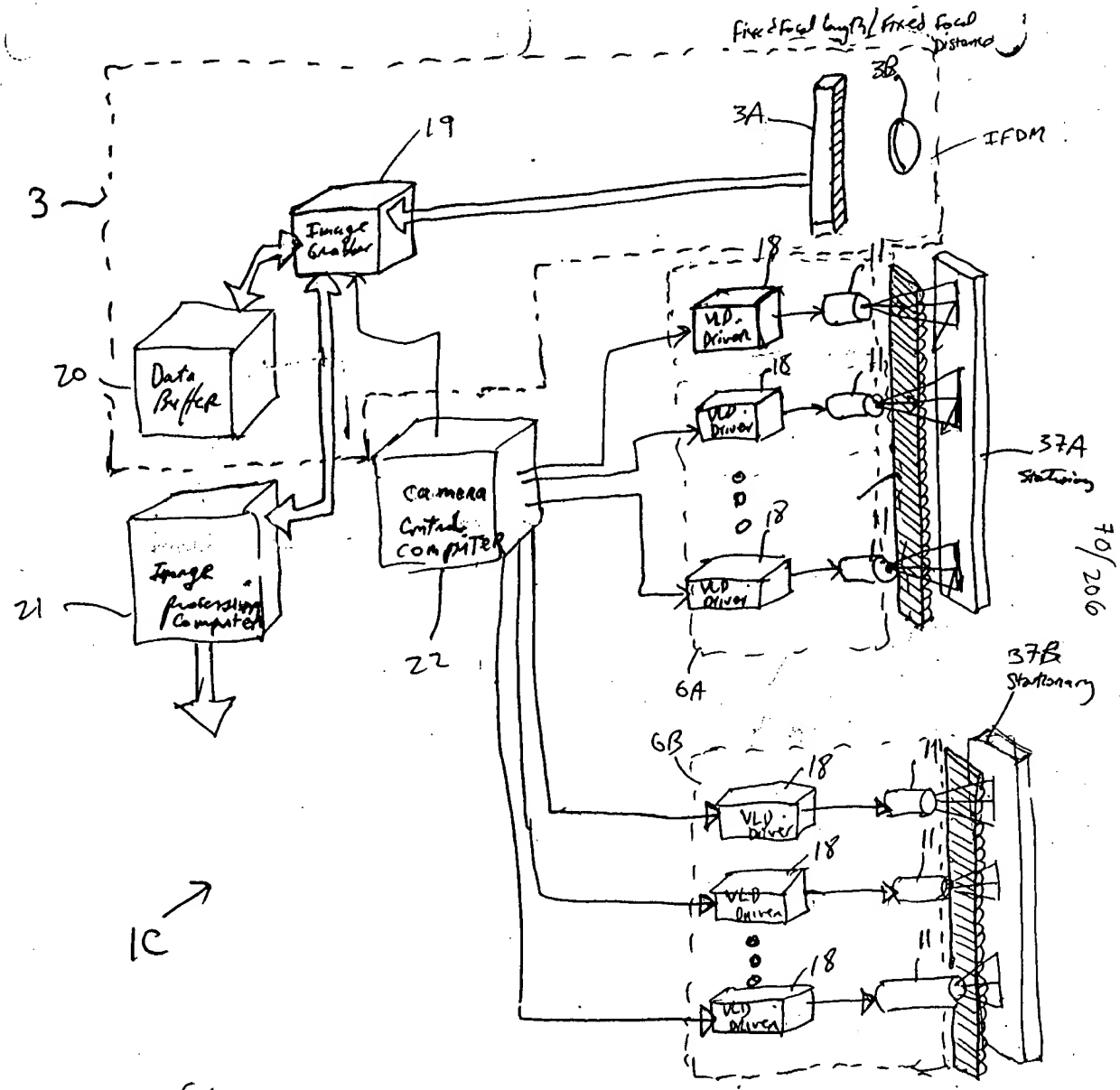

Fixed Focal Length/ Fixed Focal Distance
3B
3A
IFDM
3
19
Image Grabber
20
Data Buffer
21
Image Processing Computer
Camera Control Computer
22
18
VLD Driver
37A
Stationary
6A
37B
Stationary
6B
1C

FIG. 1R2

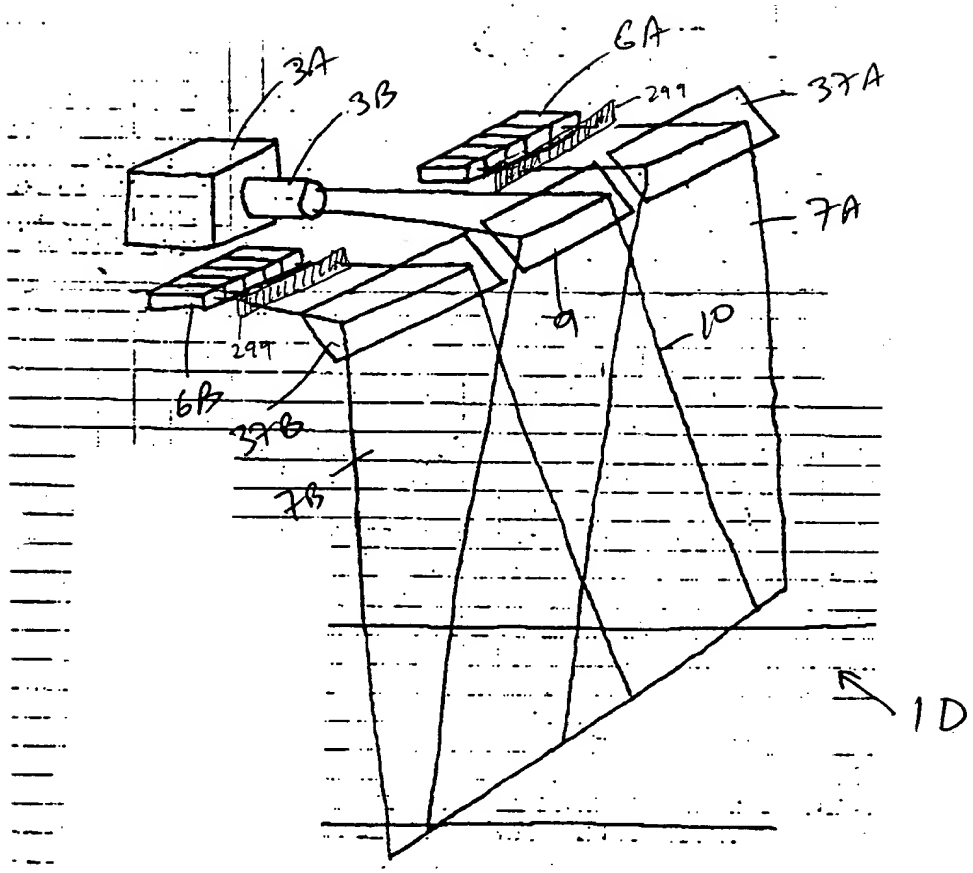


FIG. 1S1

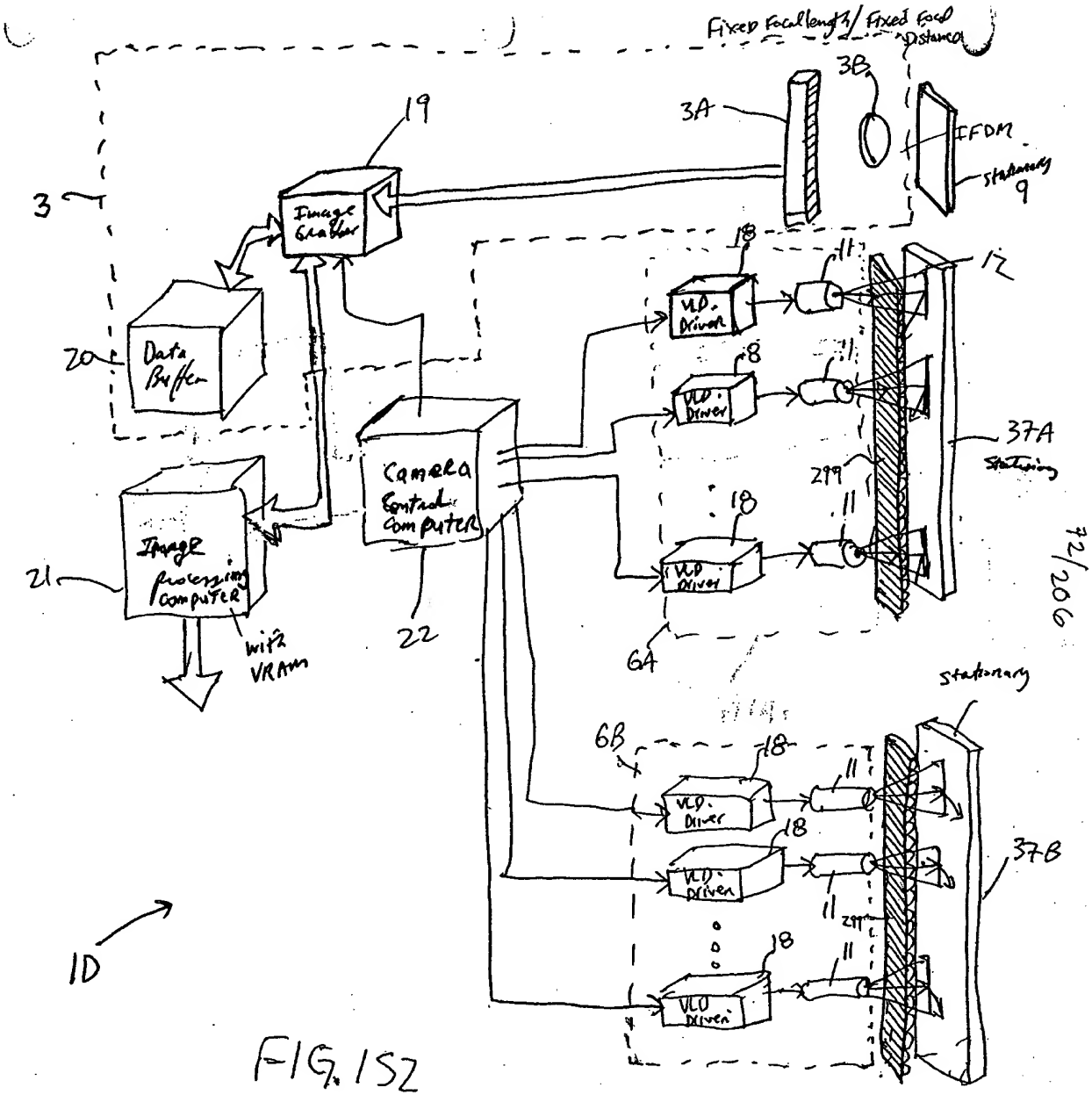

Fixed Focallength/ Fixed Focal Distance
3B
3A
FFDM
stationary
9
19
3
Image Grabber
18
11
12
VLD Driver
20
Data Buffer
8
37A
299
Camera Control computer
Image processing computer
21
with VRAM
22
64
72/206
stationary
6B
37B
1D

FIG. 15Z

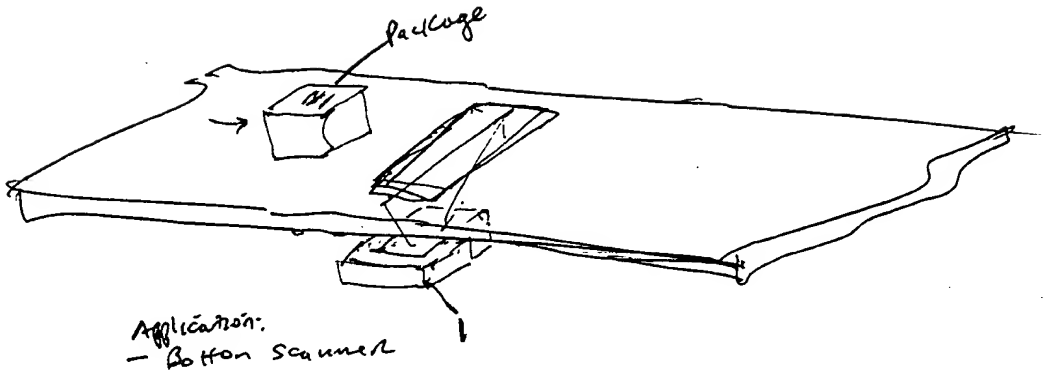


FIG 1T

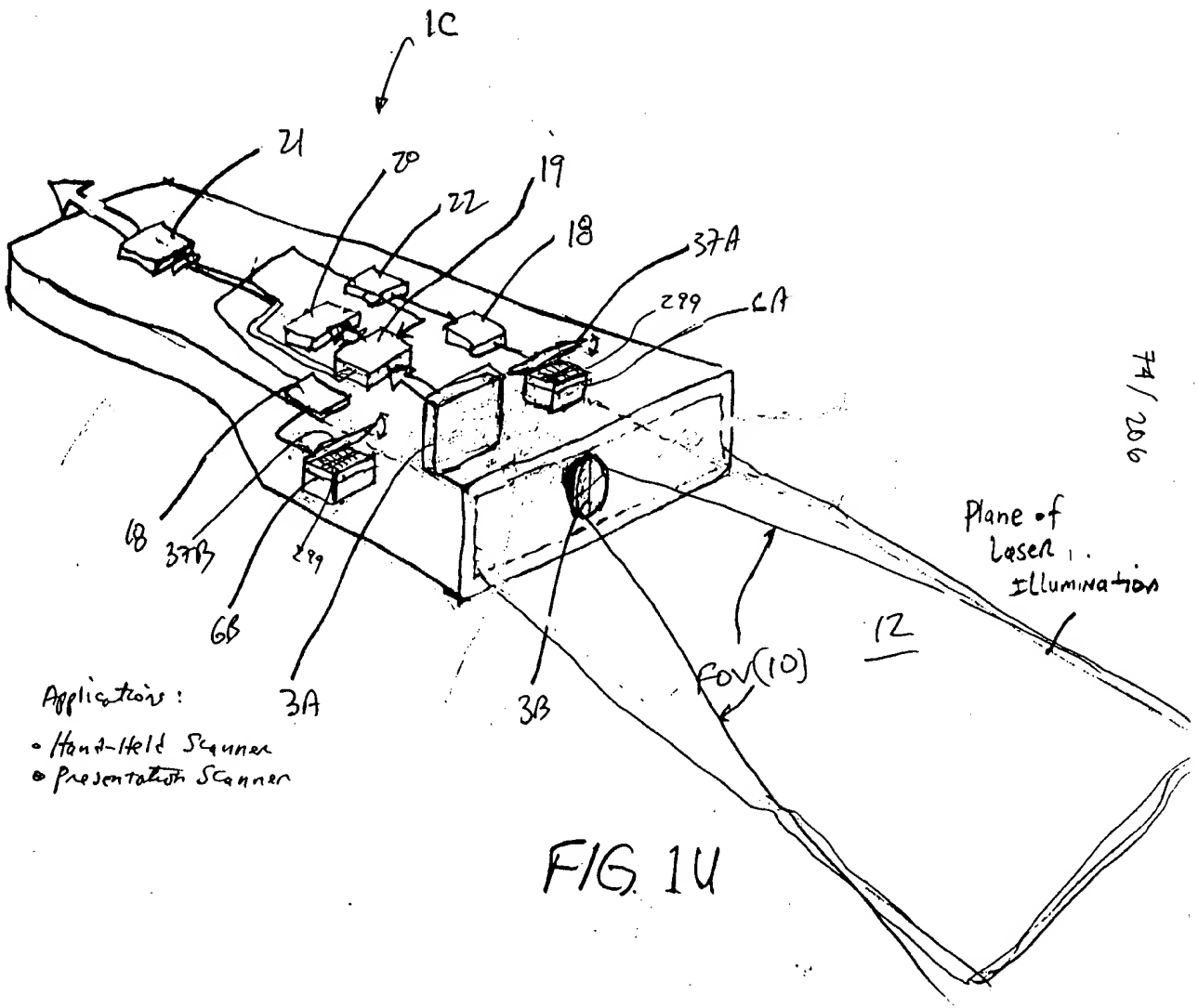


FIG. 1U

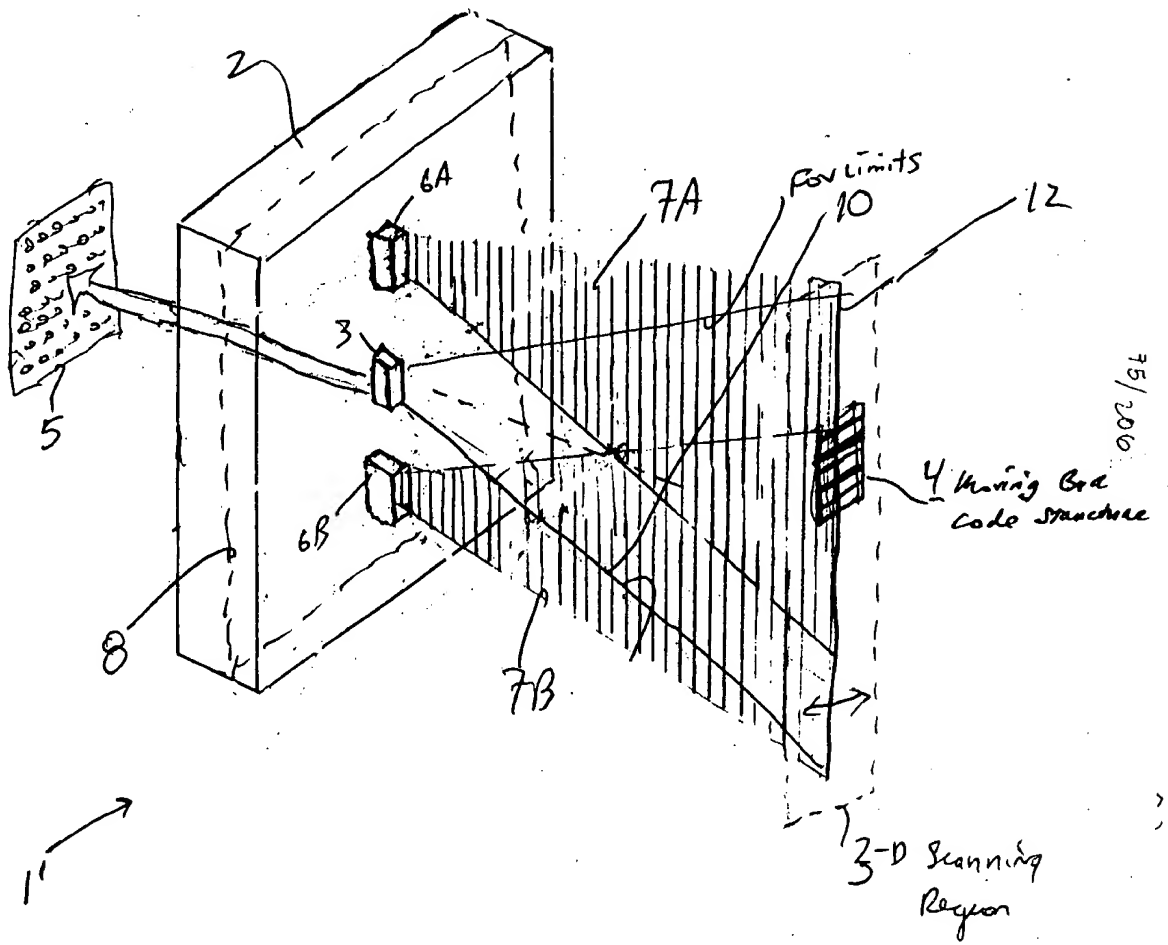


FIG. IVI

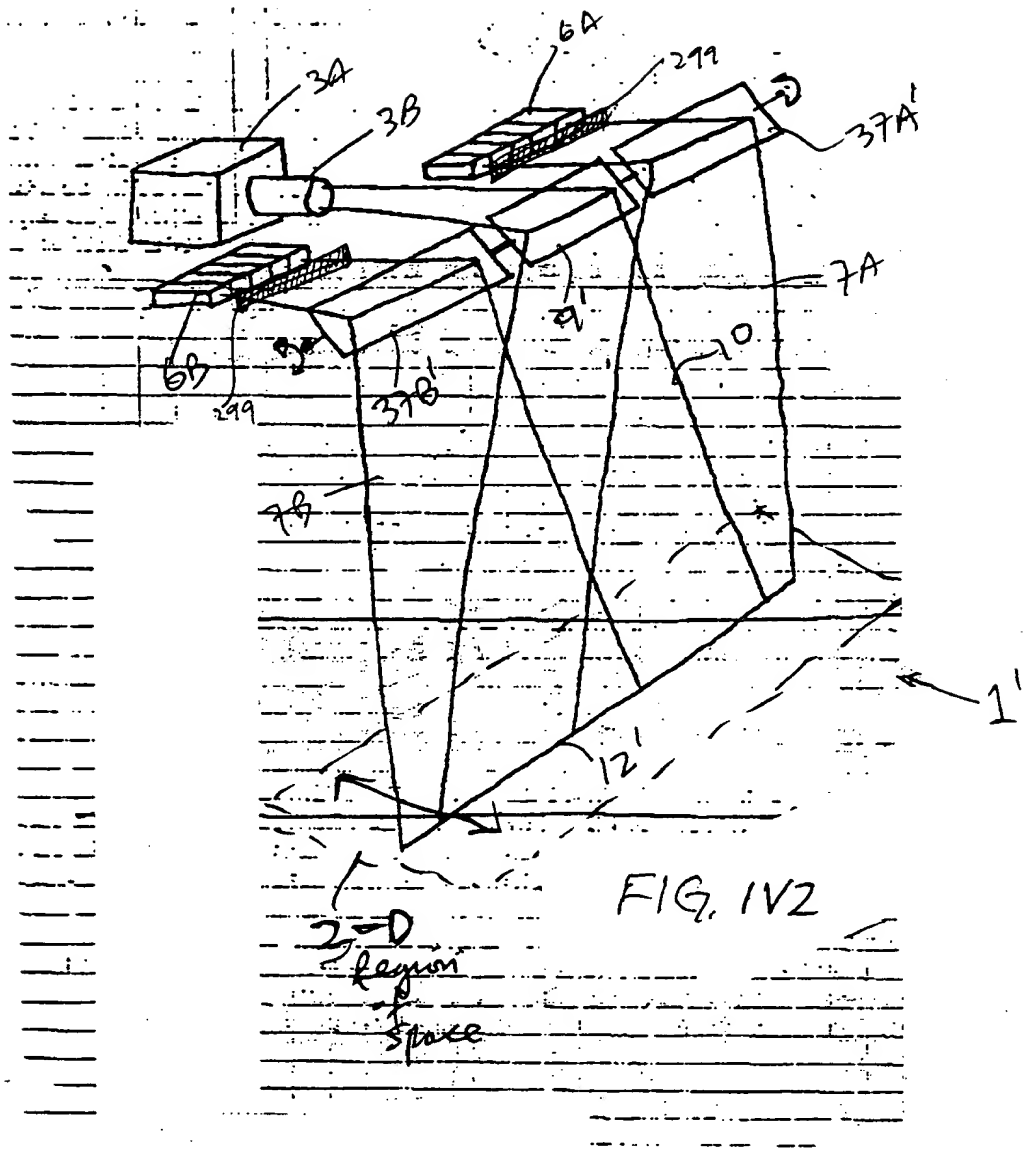


FIG. 1V2

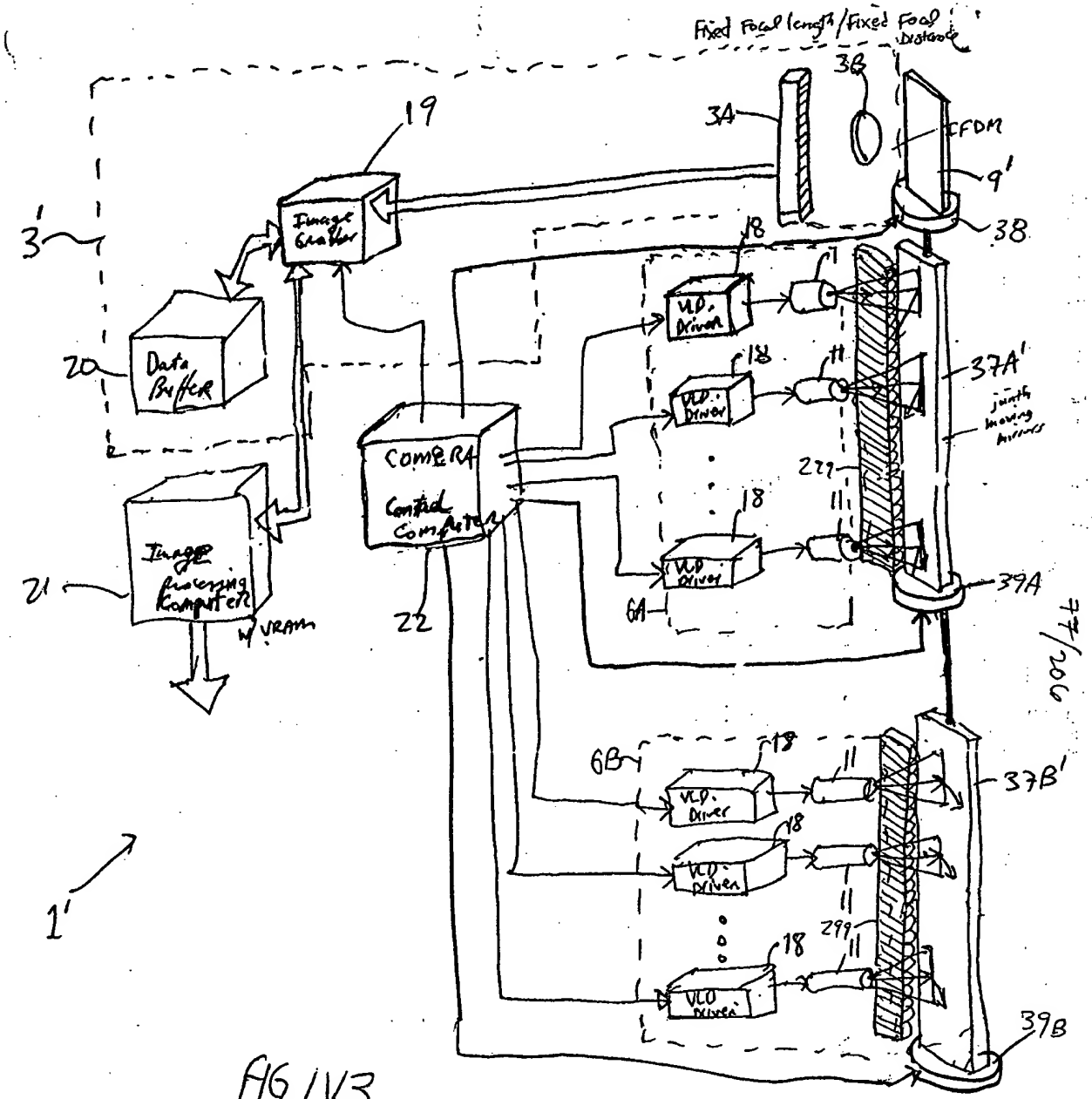

Fixed Focal length/Fixed Focal Distance
3B
3A
CFDM
9'
38
19
Image Grabber
3'
18
VLD Driver
20
Data Buffer
37A'
Joints moving mirrors
COMERA
Control Computer
229
18
21
Image Processing Computer
W VRAM
22
39A
6A
74/206
6B
18
37B'
VLD Driver
299
39B
1'

FIG. 1V3

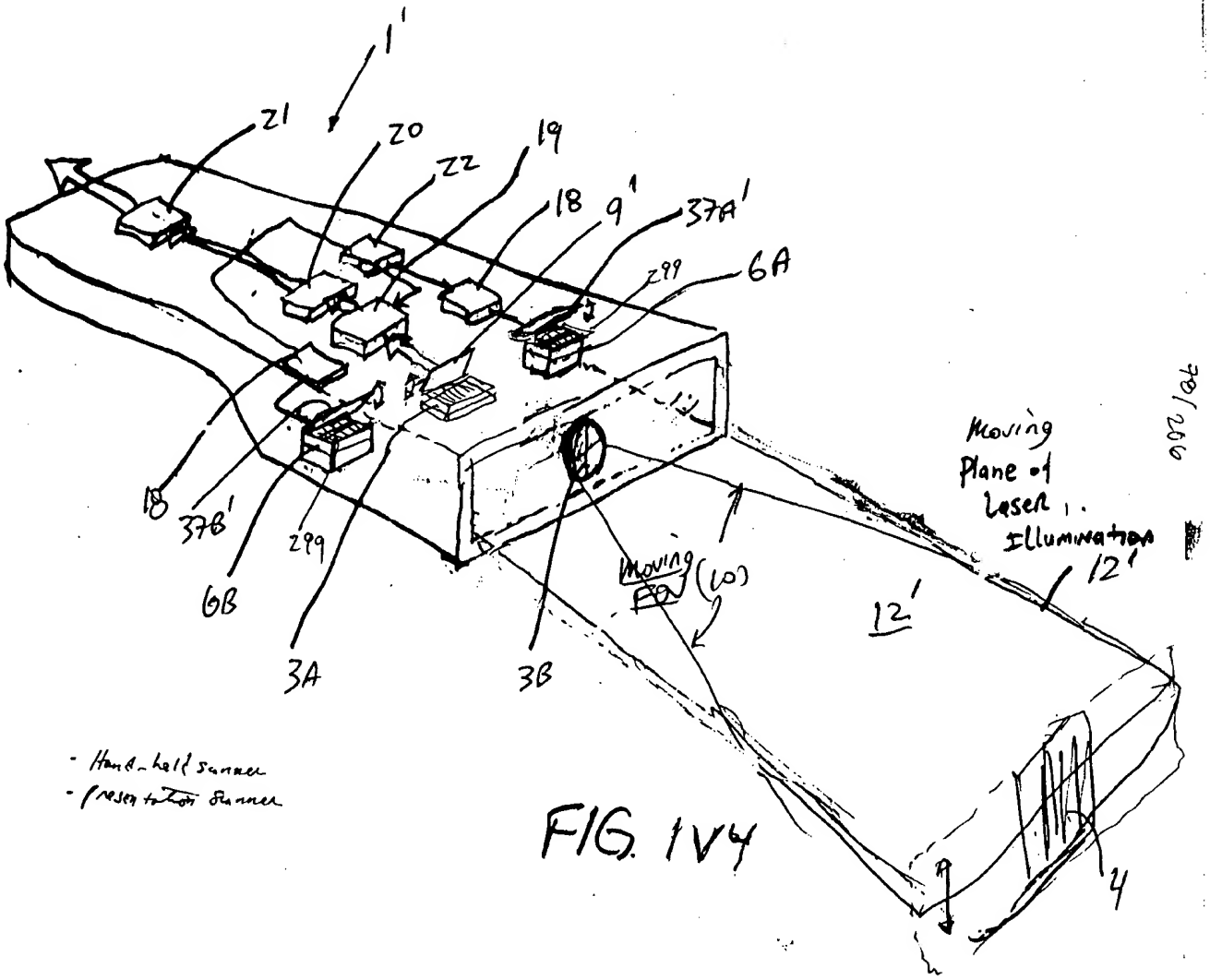
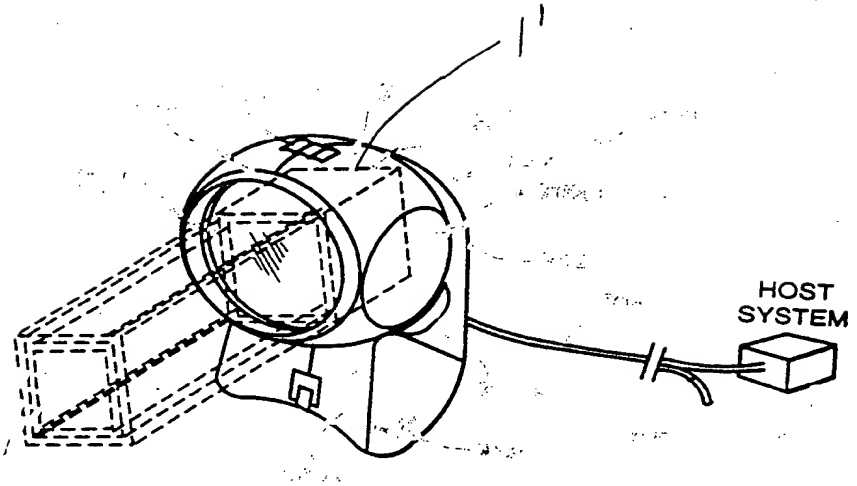
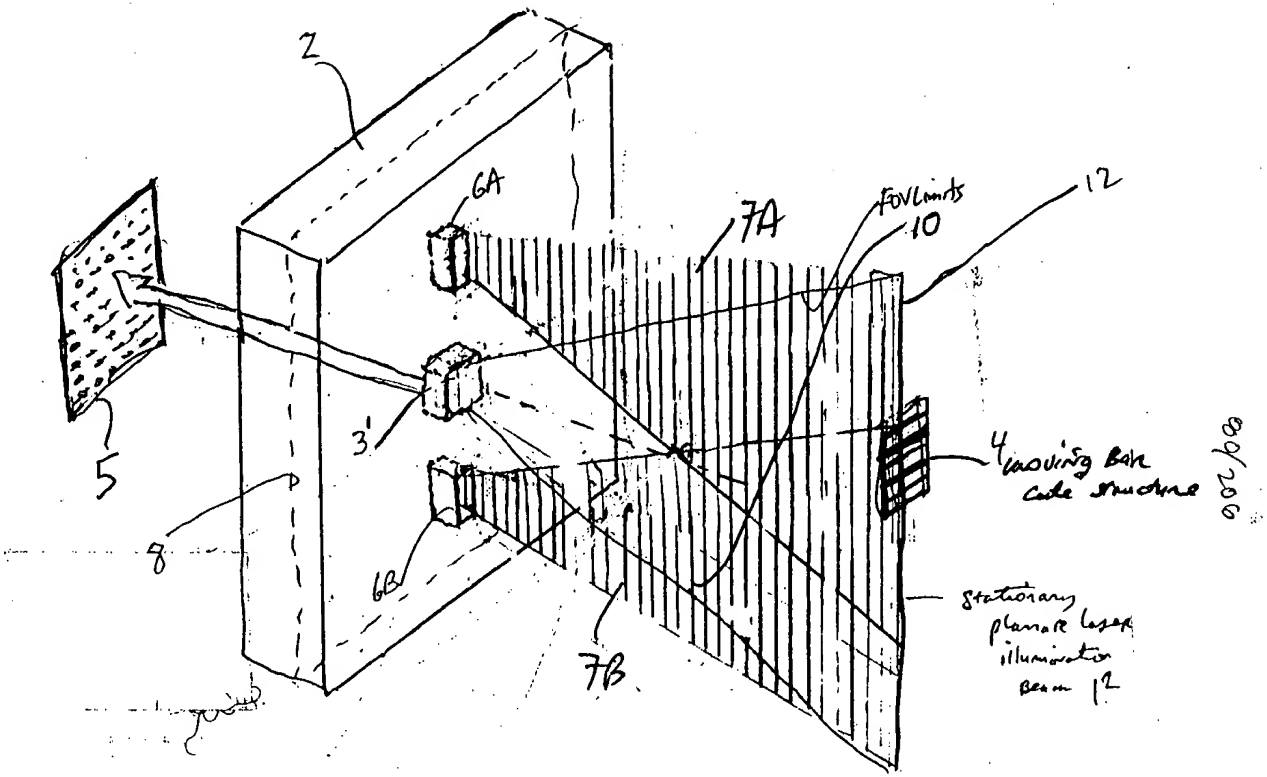


FIG. 1V4



(Presentation type scanner)

FIG. 1V5


2
6A
7A
FOV limits
10
12
5
3'
4 Housing Bar code structure
8
6B
7B
Stationary planar laser illumination beam 12

40

FIG. 2A

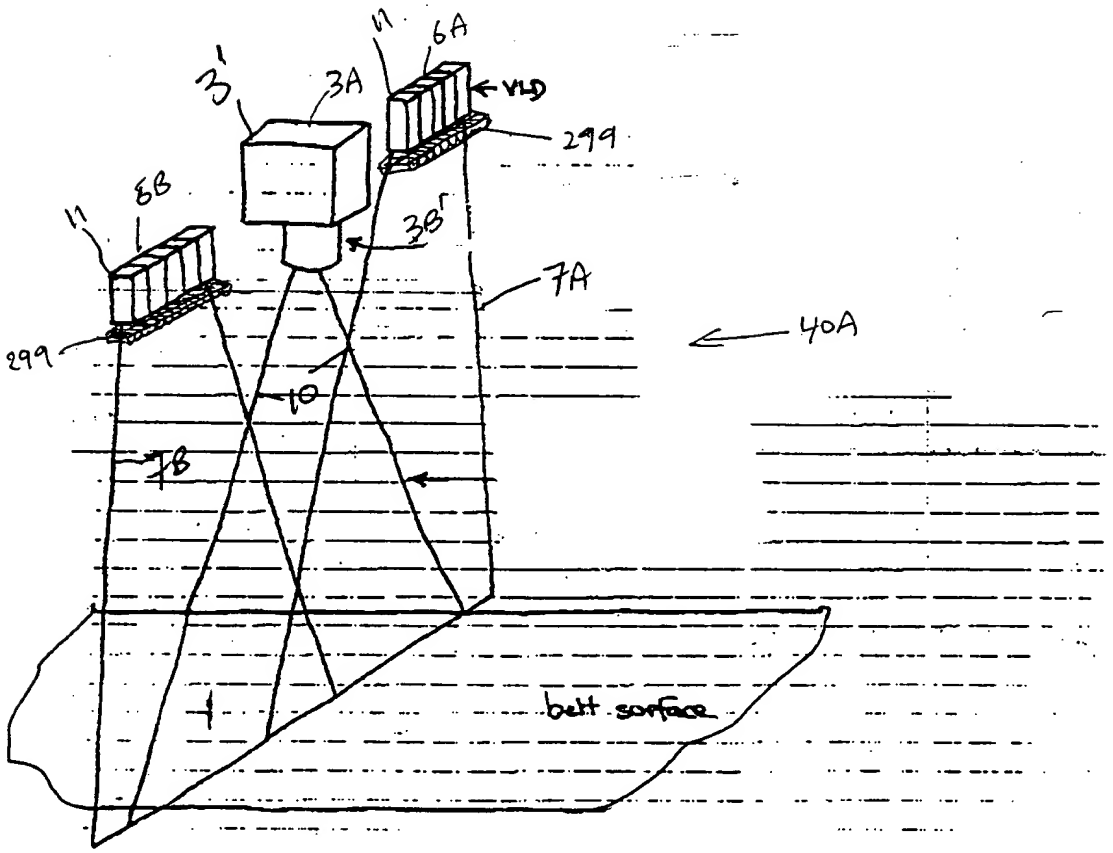


FIG. 2B1

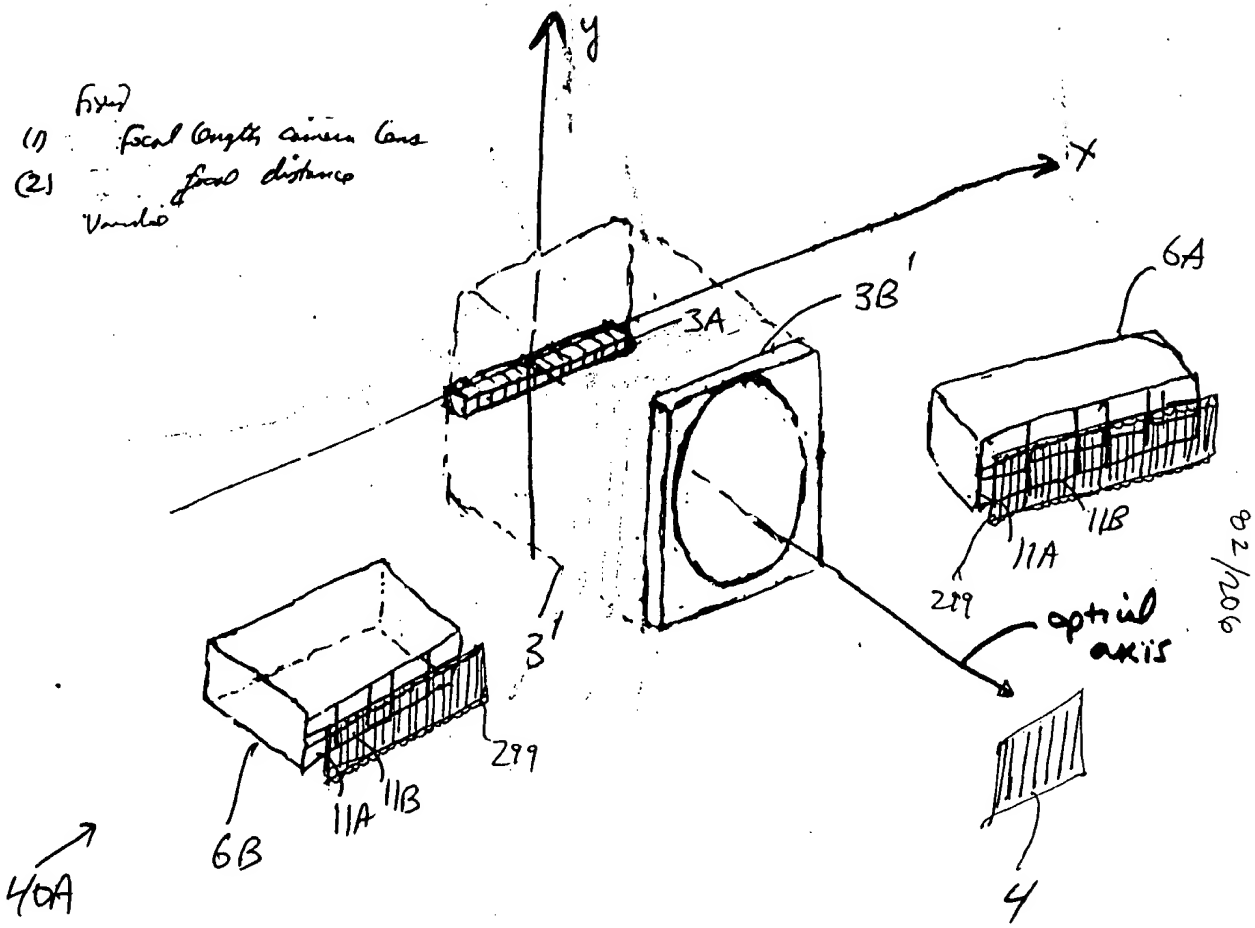


FIG. 2B2

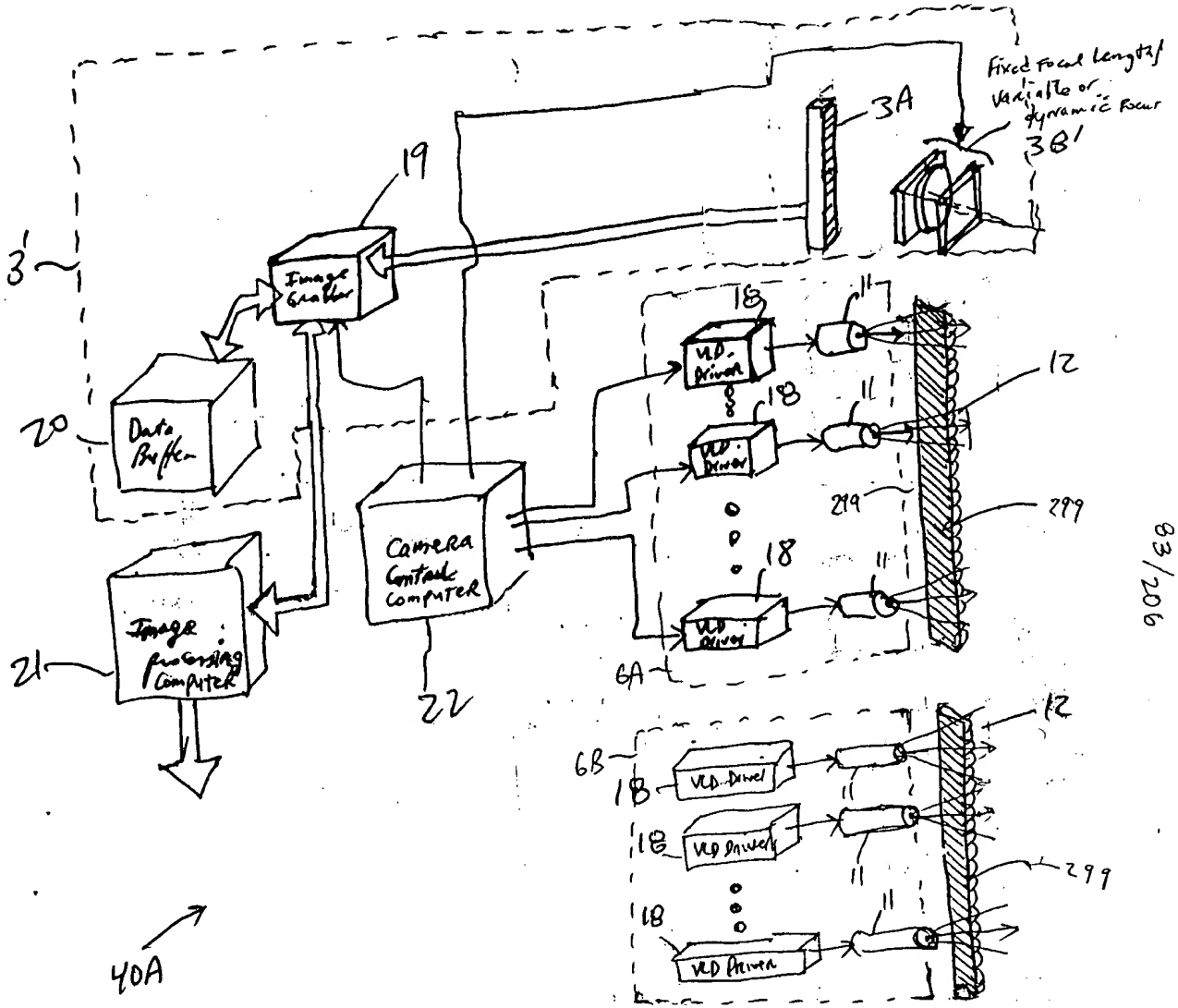

Fixed Focal Length/
Variable or
dynamic Focus
3A
3B'
19
3'
Image Grabber
18
VLD Driver
11
12
20
Data Buffer
299
Camera Control Computer
Image Processing Computer
21
22
6A
6B
40A

FIG. 2C1

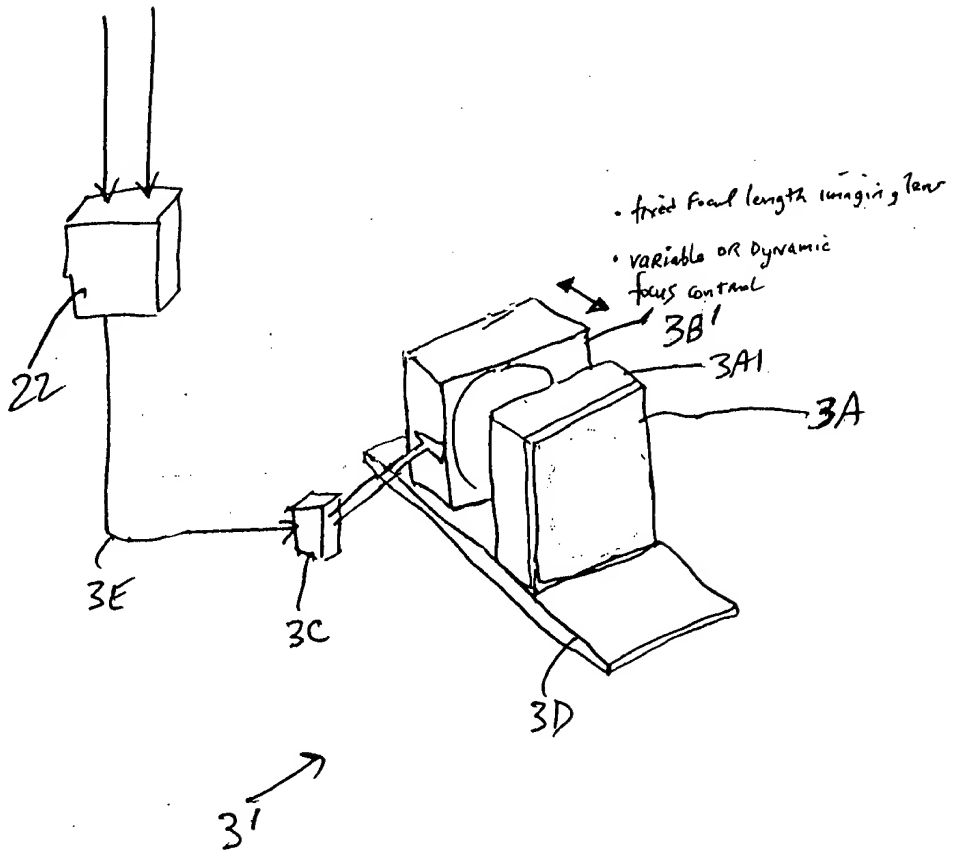

• fixed Focal length imaging lens
• variable or Dynamic focus control
3B'
3A1
3A
22
3E
3C
3D
3'

FIG. 2C2

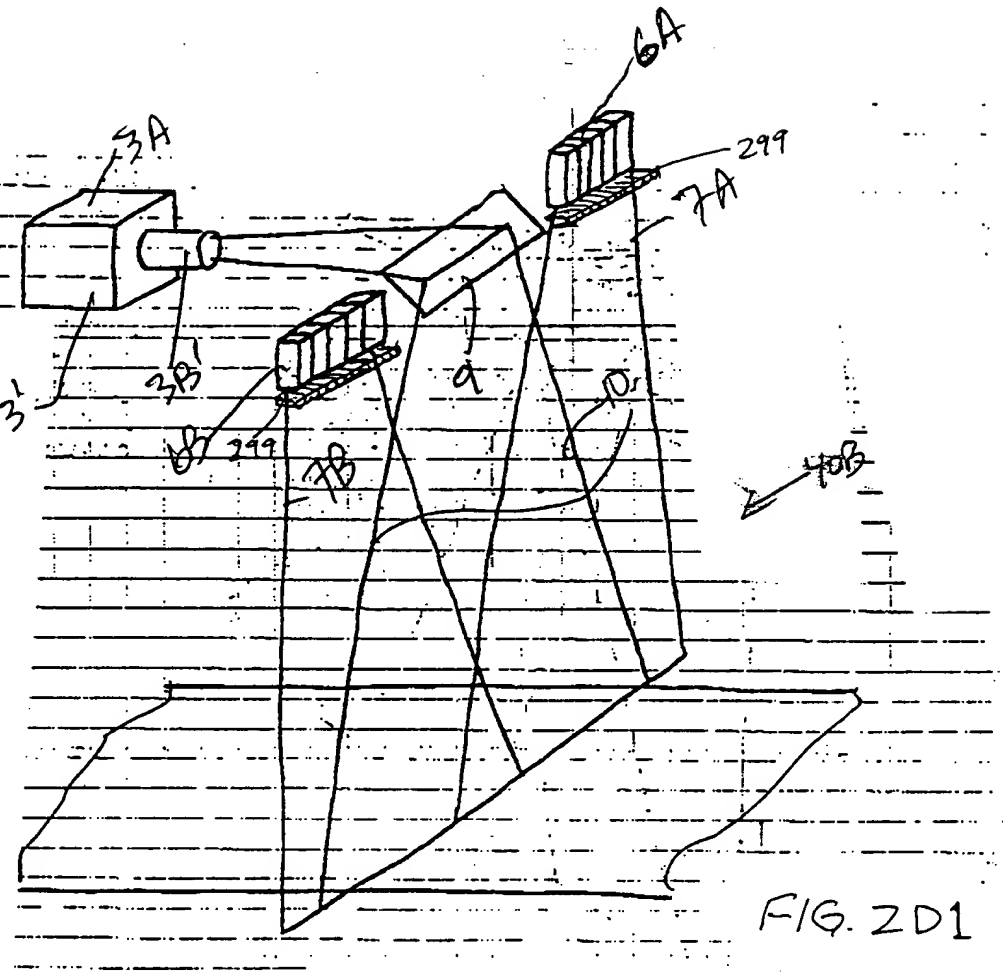


FIG. 2D1

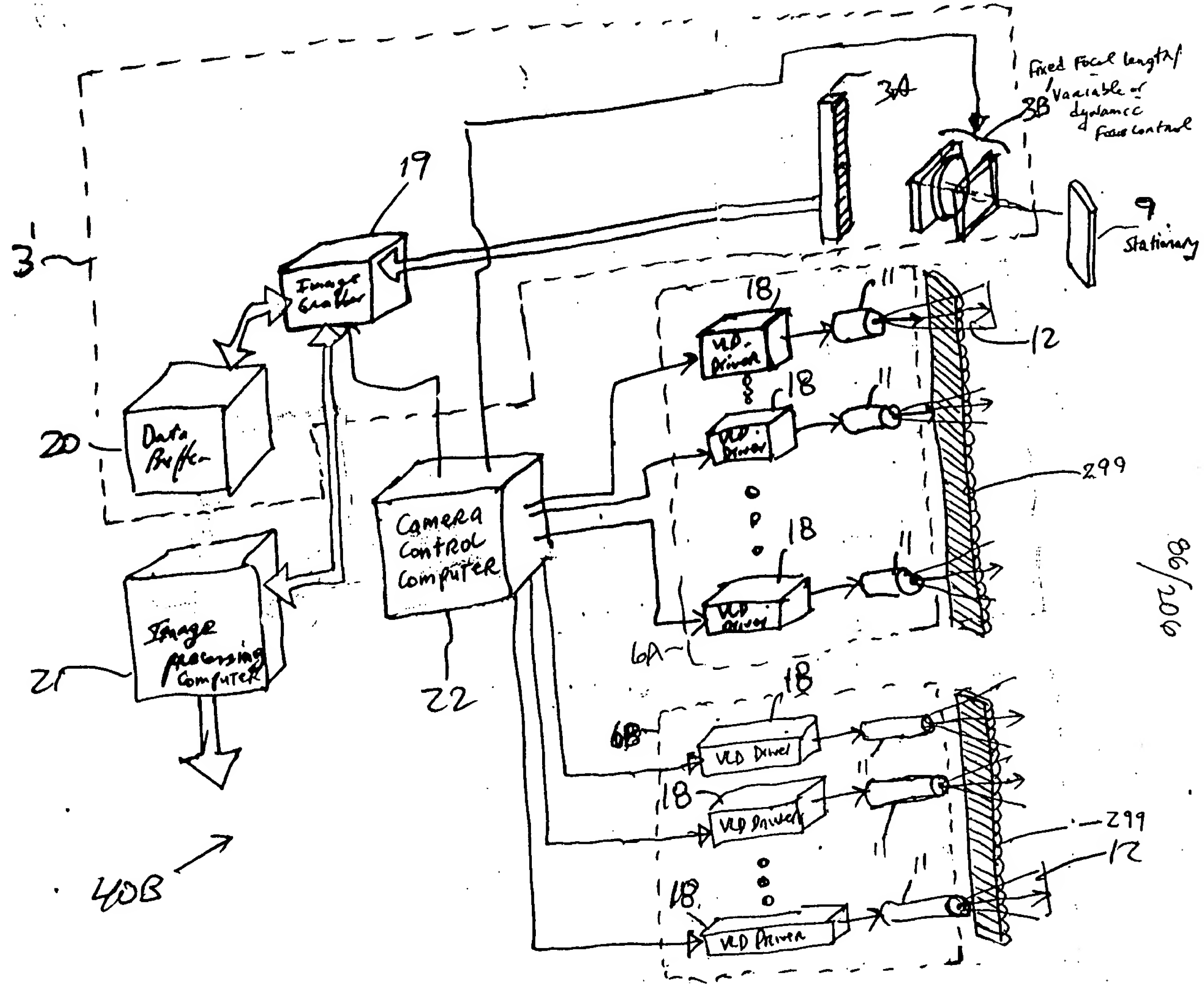


FIG. 2D2

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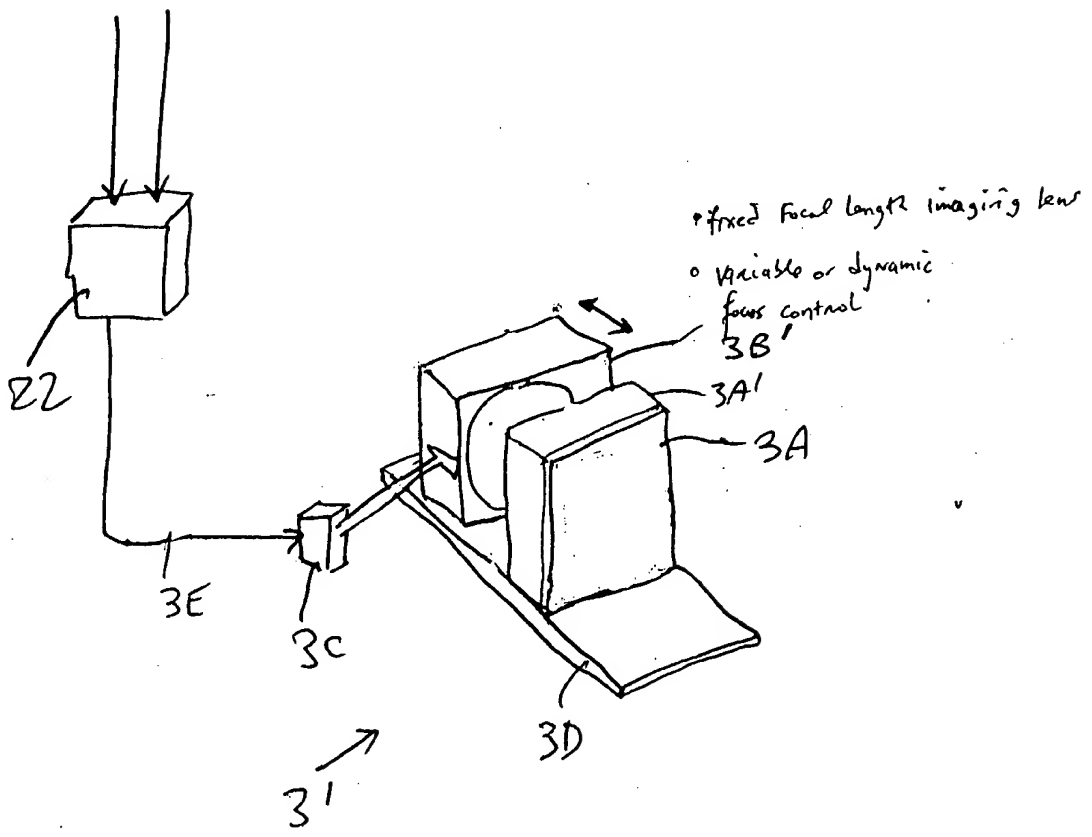

• fixed Focal length imaging lens
o variable or dynamic focus control
3B'
3A'
3A
22
3E
3c
3D
3'

FIG. 2D3

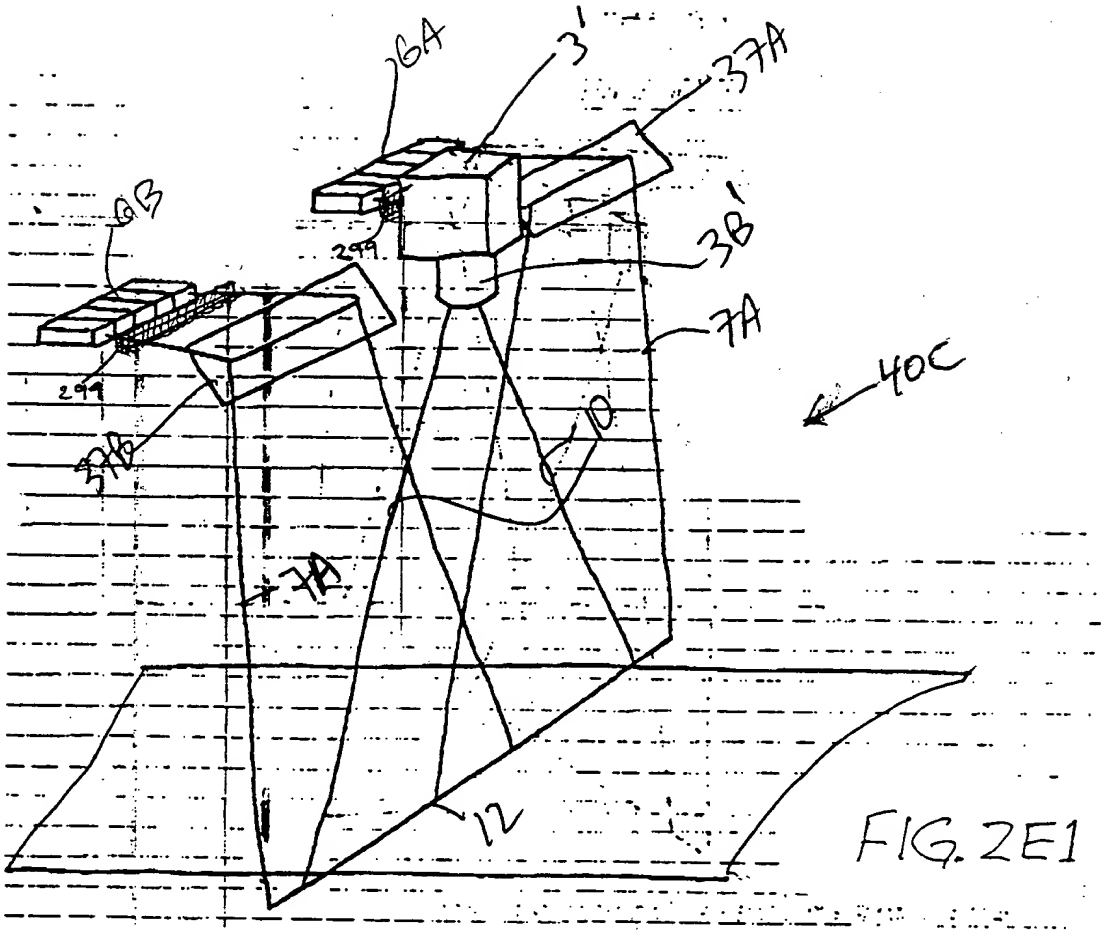


FIG. 2E1

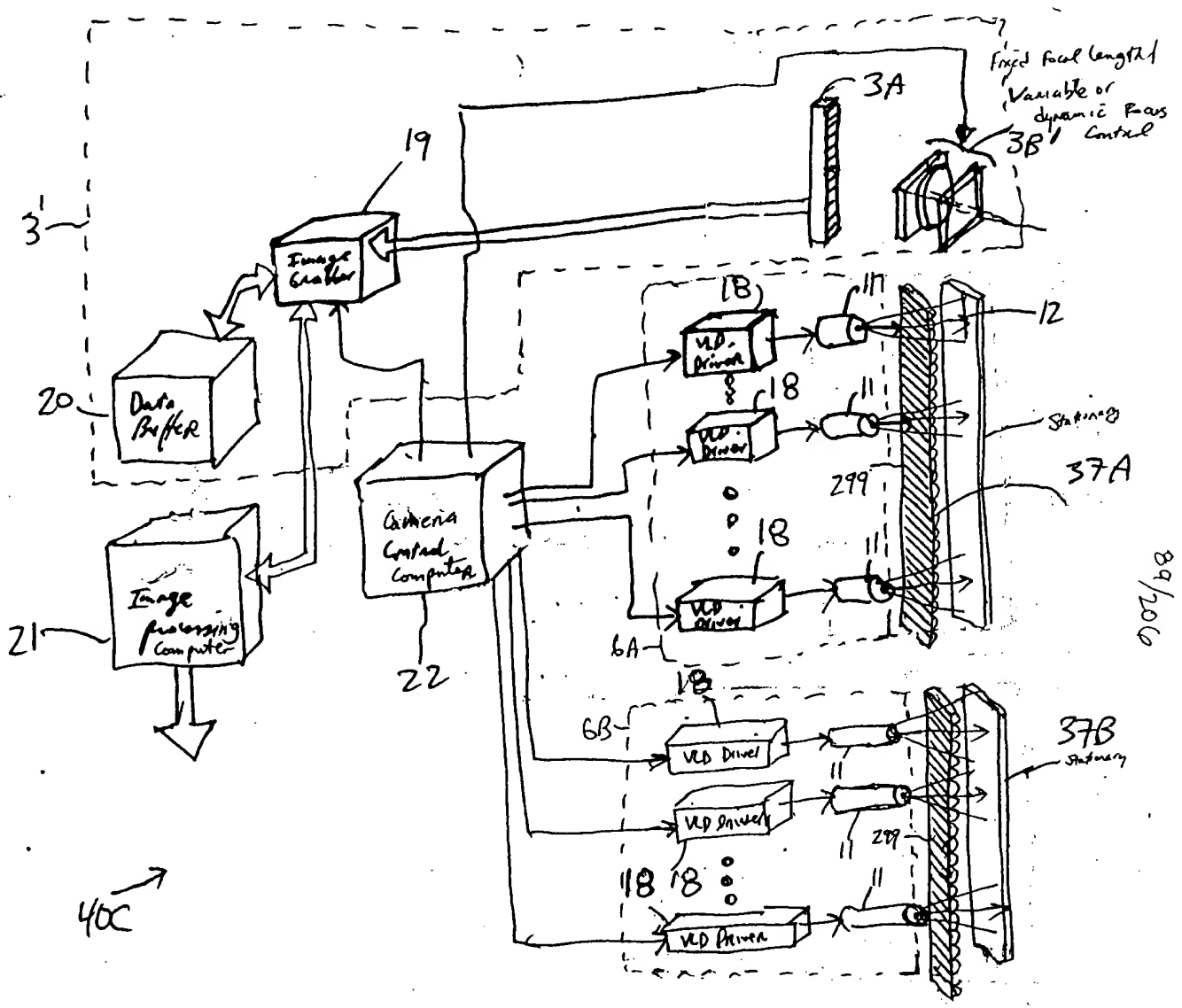

Fixed Focal Length/
Variable or
dynamic Focus
Control
3A
3B
19
3'
Image Grabber
20
Data Buffer
21
Image processing Computer
Camera Control Computer
22
(B)
VLD Driver
18
11
12
299
37A
6A
6B
37B
40C

FIG. 2E2

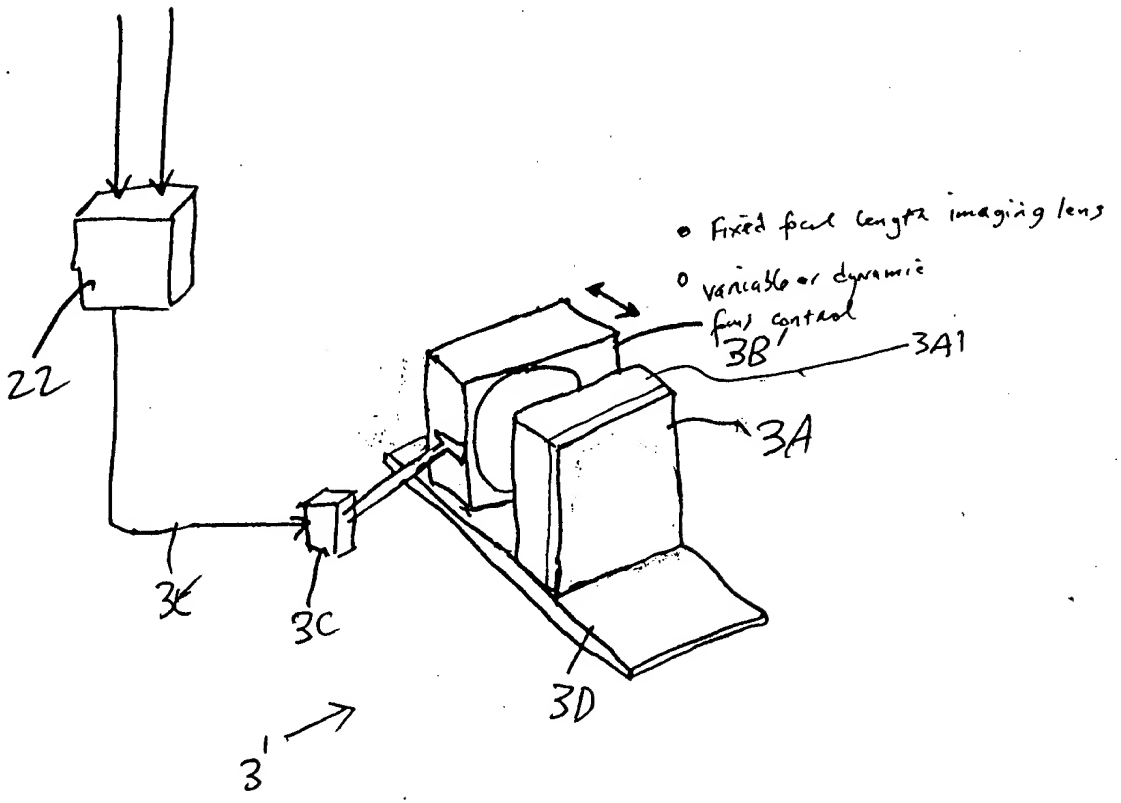

• fixed focal length imaging lens
• variable or dynamic focus control
3B'
3A1
3A
22
3C
3D
3'

FIG. 2E3

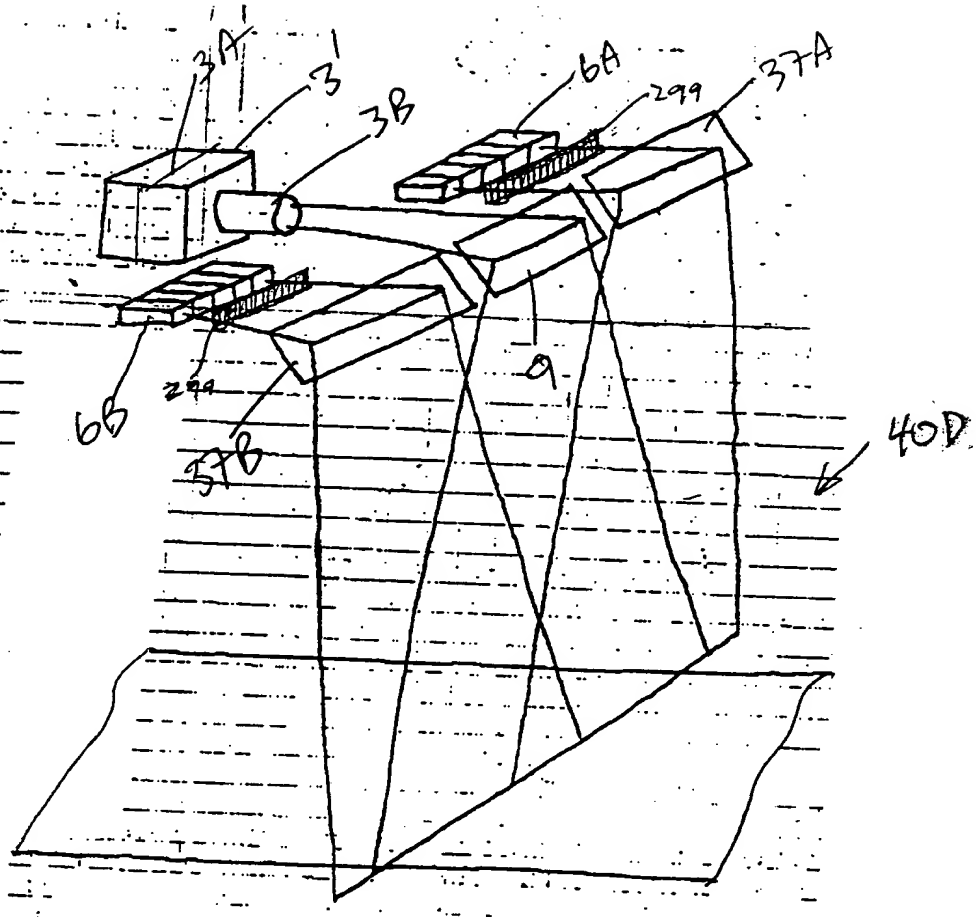


FIG. 2F1

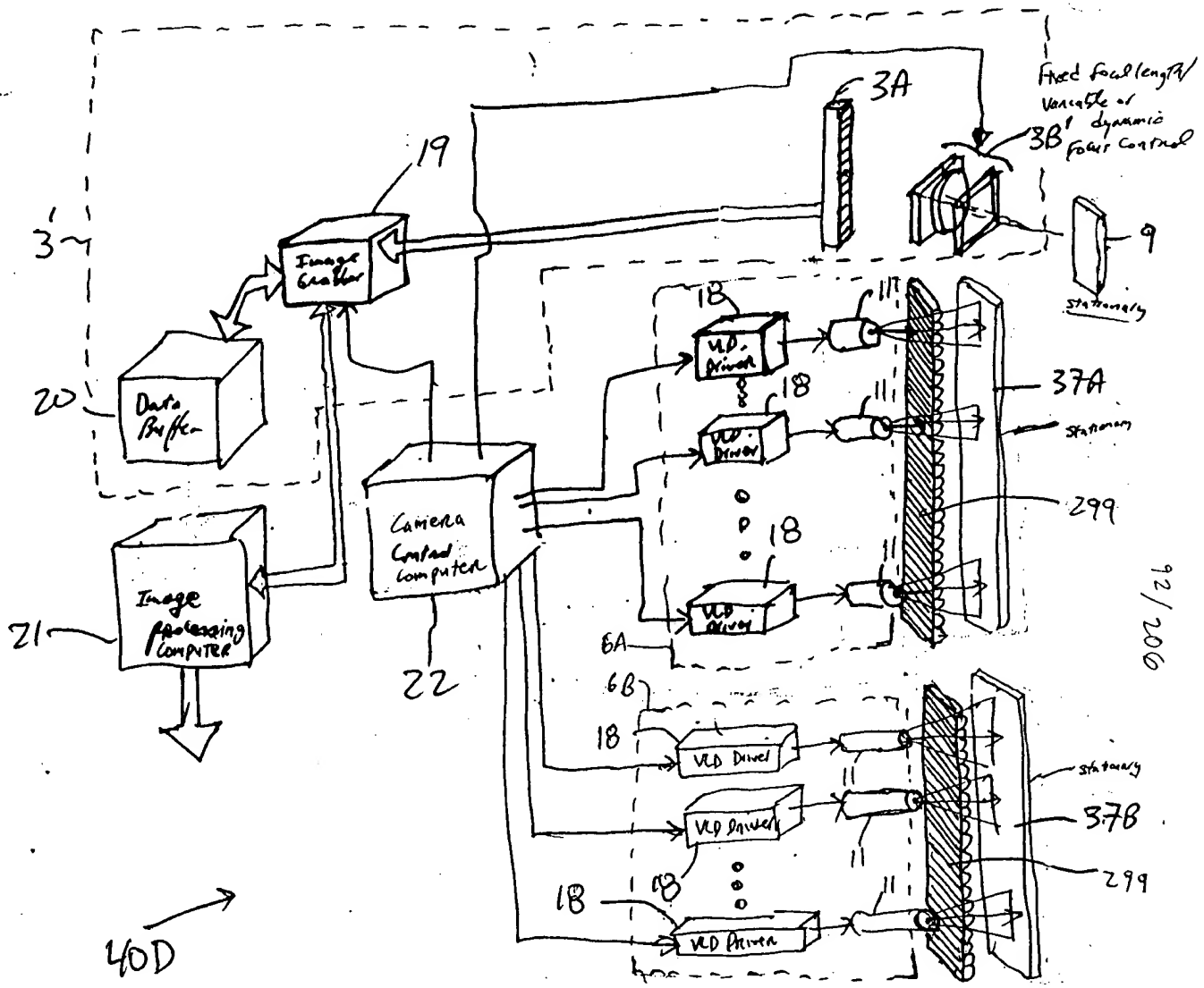


FIG 2F2

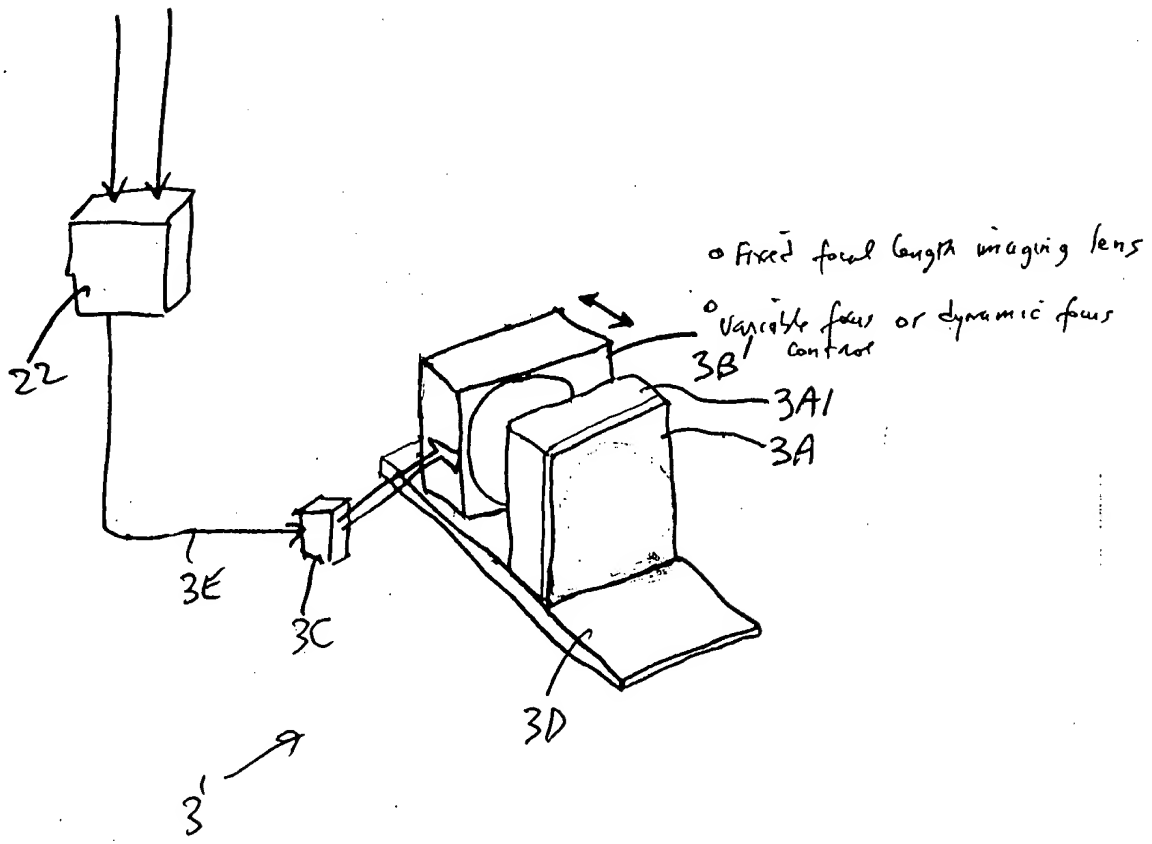
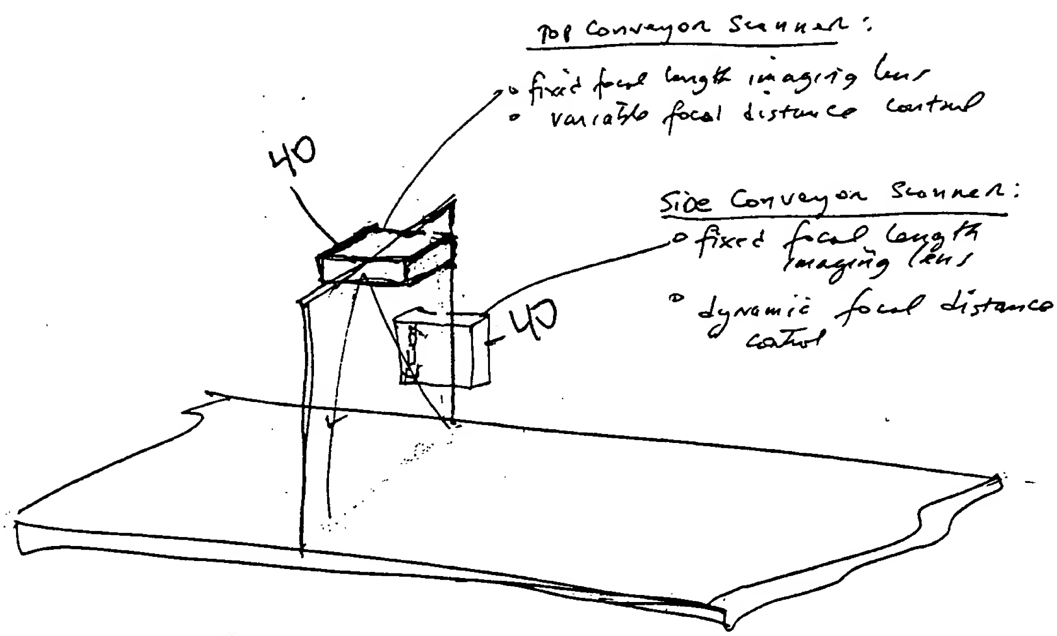

o Fixed focal length imaging lens
o Variable focus or dynamic focus control
22
3B
3A1
3A
3E
3C
3D
3'

FIG. 2F3



Top Conveyor Scanner:
fixed focal length imaging lens
variable focal distance control
40
Side Conveyor Scanner:
fixed focal length imaging lens
dynamic focal distance control
40

FIG. 2G

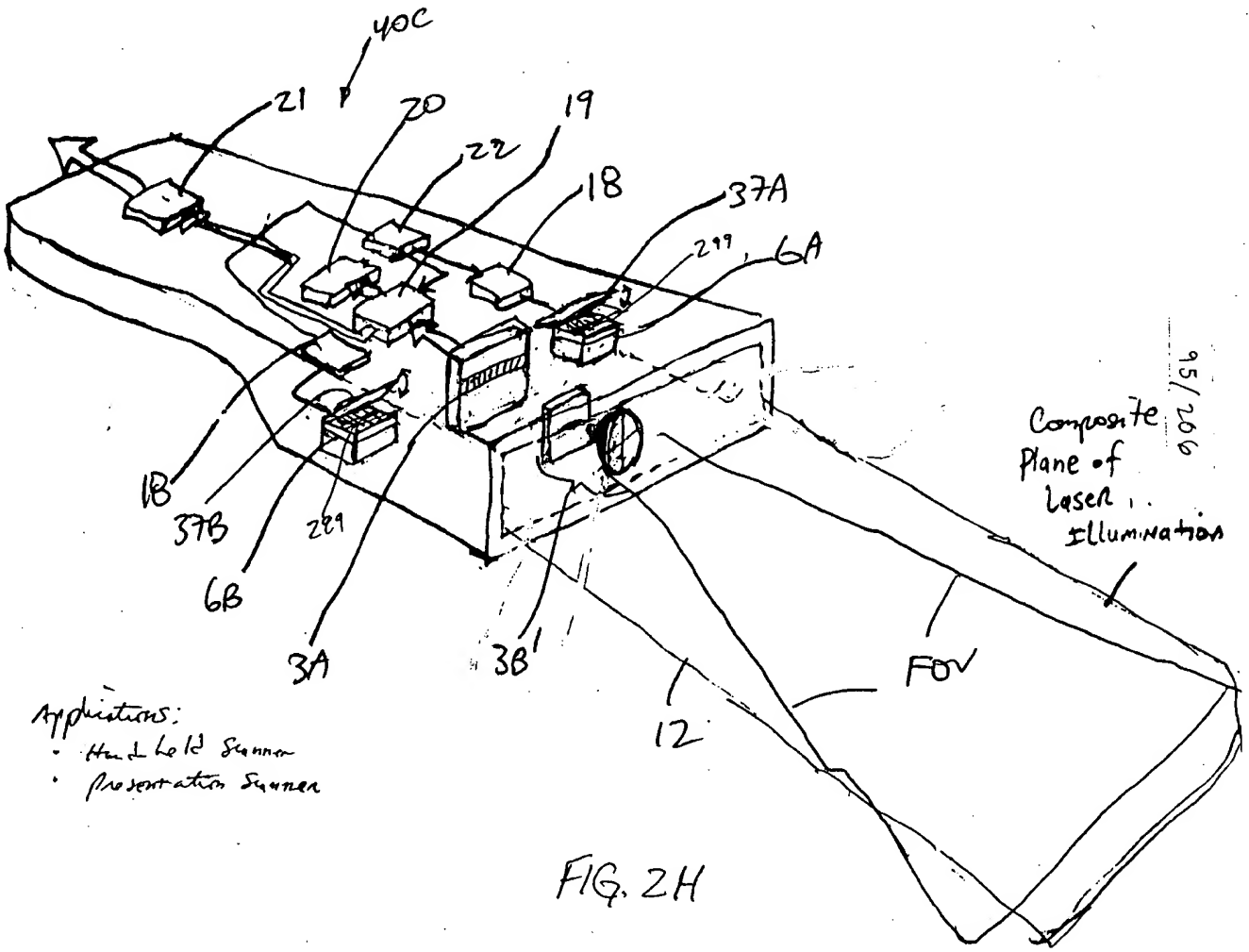

40C
21
20
22
19
18
37A
29'
6A
1B
37B
29
6B
3A
3B'
12
FOV
Composite
Plane of
Laser
Illumination
95/206
Applications:
• Hand Held Scanner
• Presentation Scanner

FIG. 2H

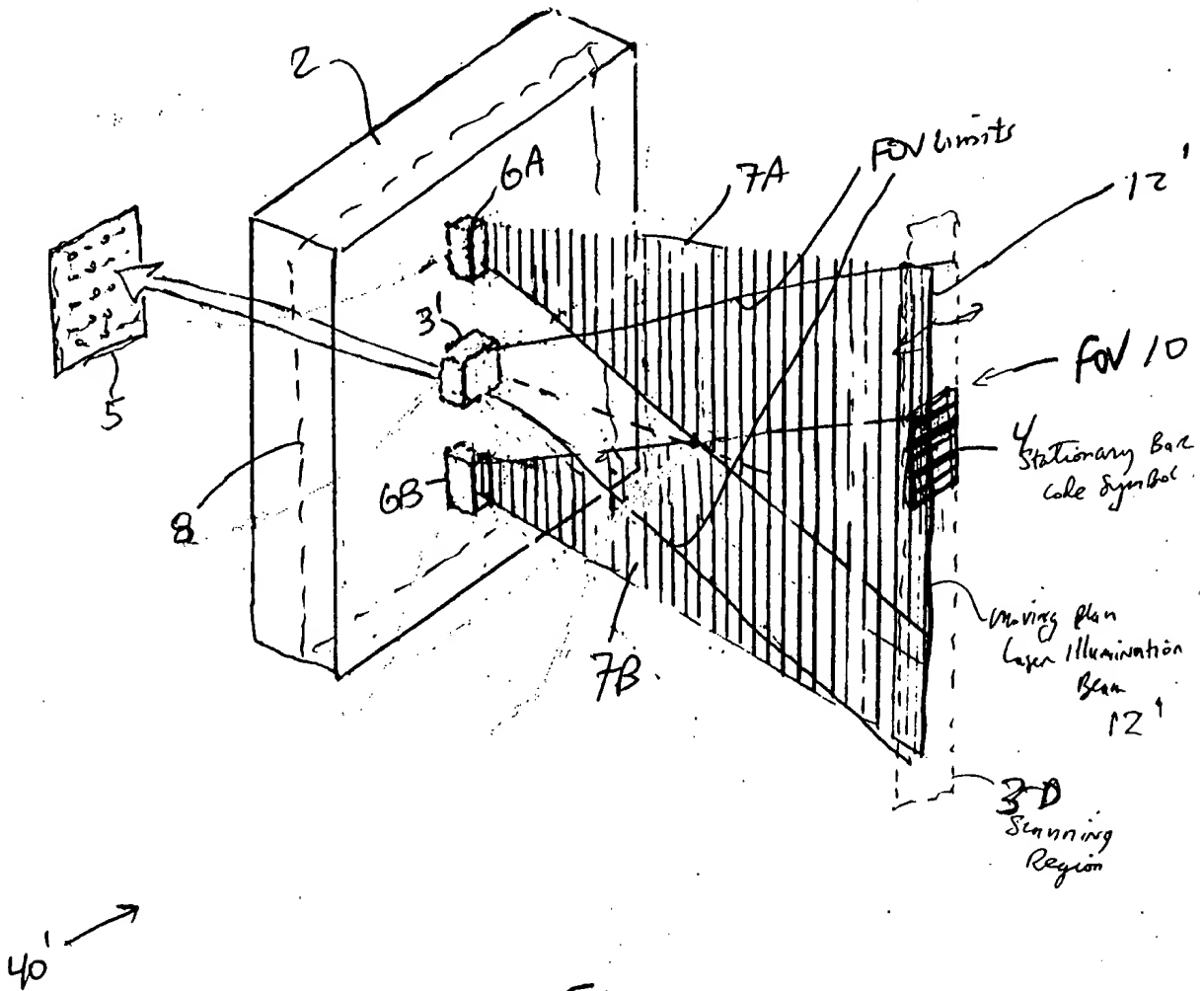

2
6A
7A
FOV limits
12'
3'
FOV 10
5
4
Stationary Bar Code Symbol
8
6B
Moving Plan Laser Illumination Beam
12'
7B
3D
Scanning Region
40'

FIG. 2I1

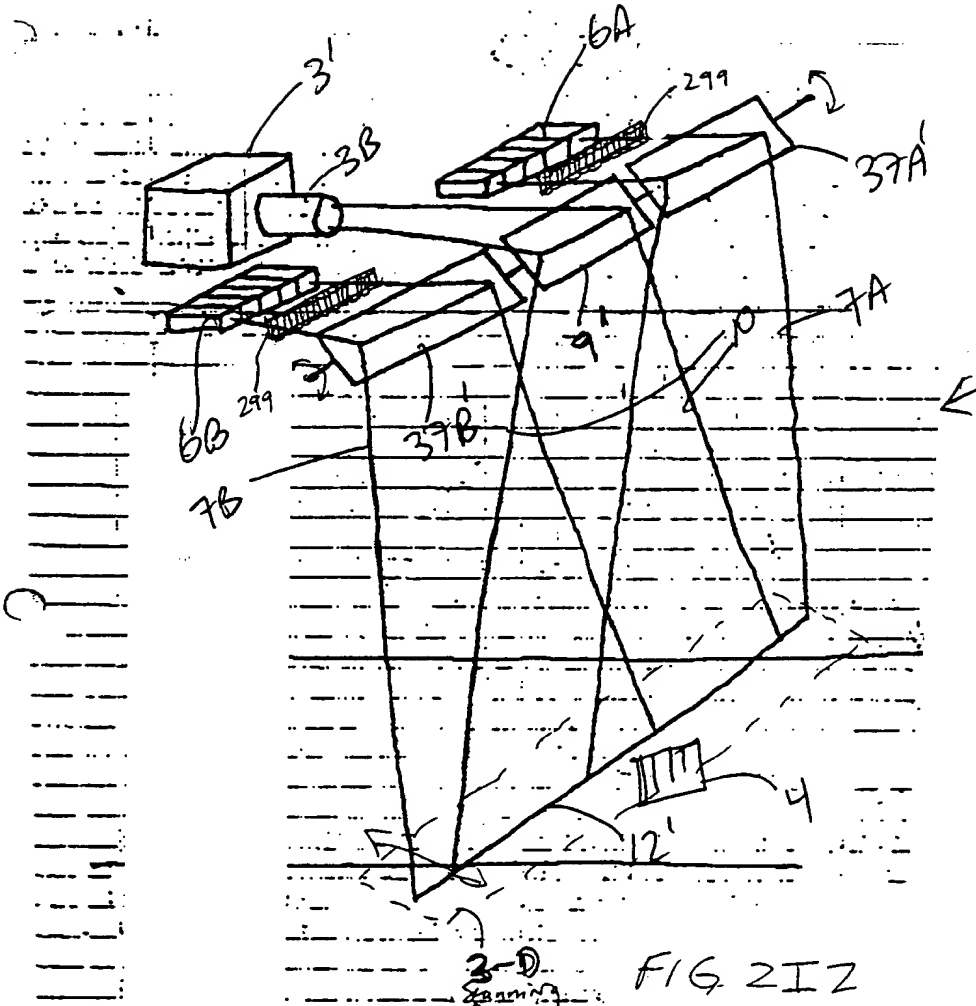


FIG 2I2

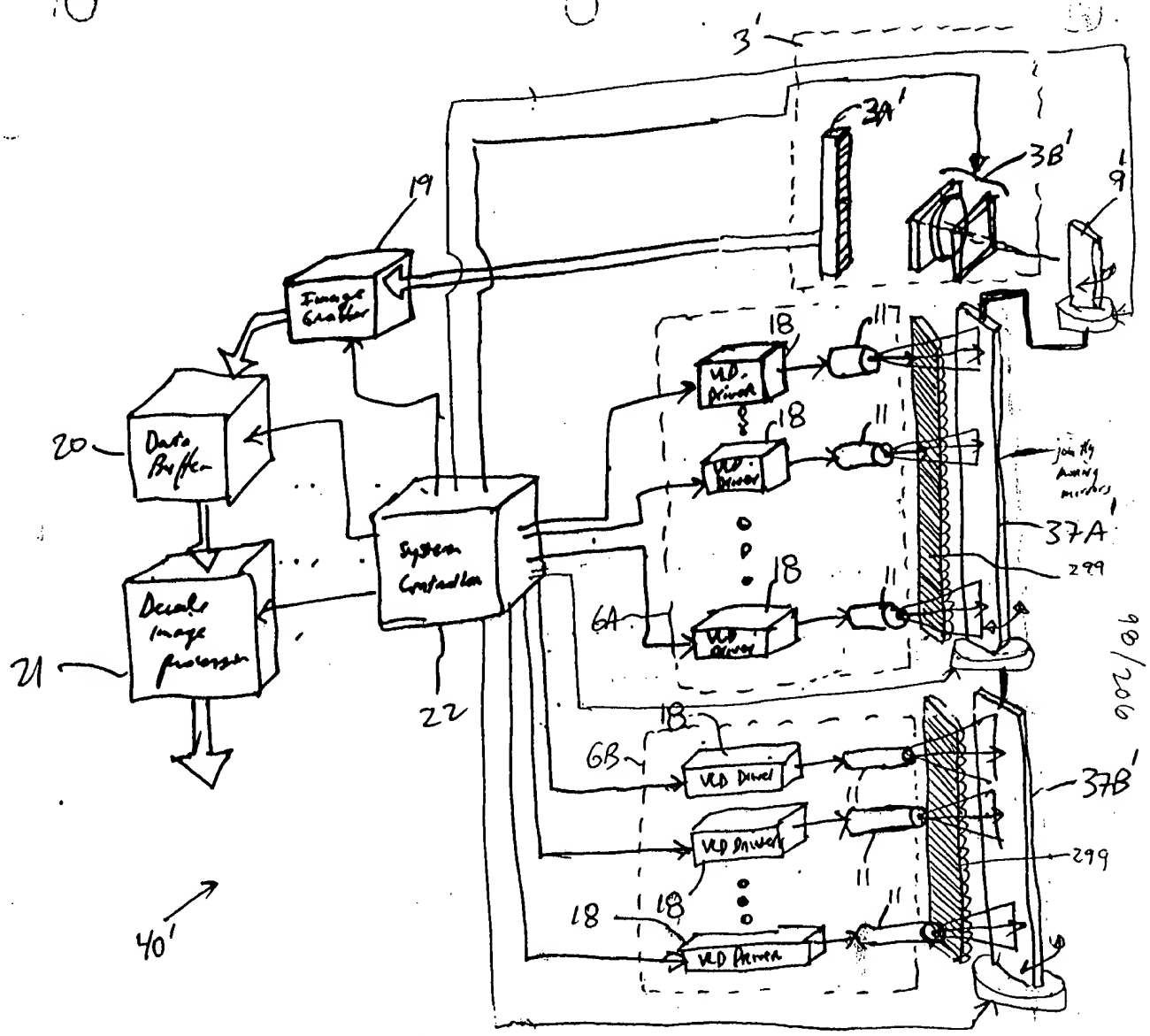


FIG. 2I3

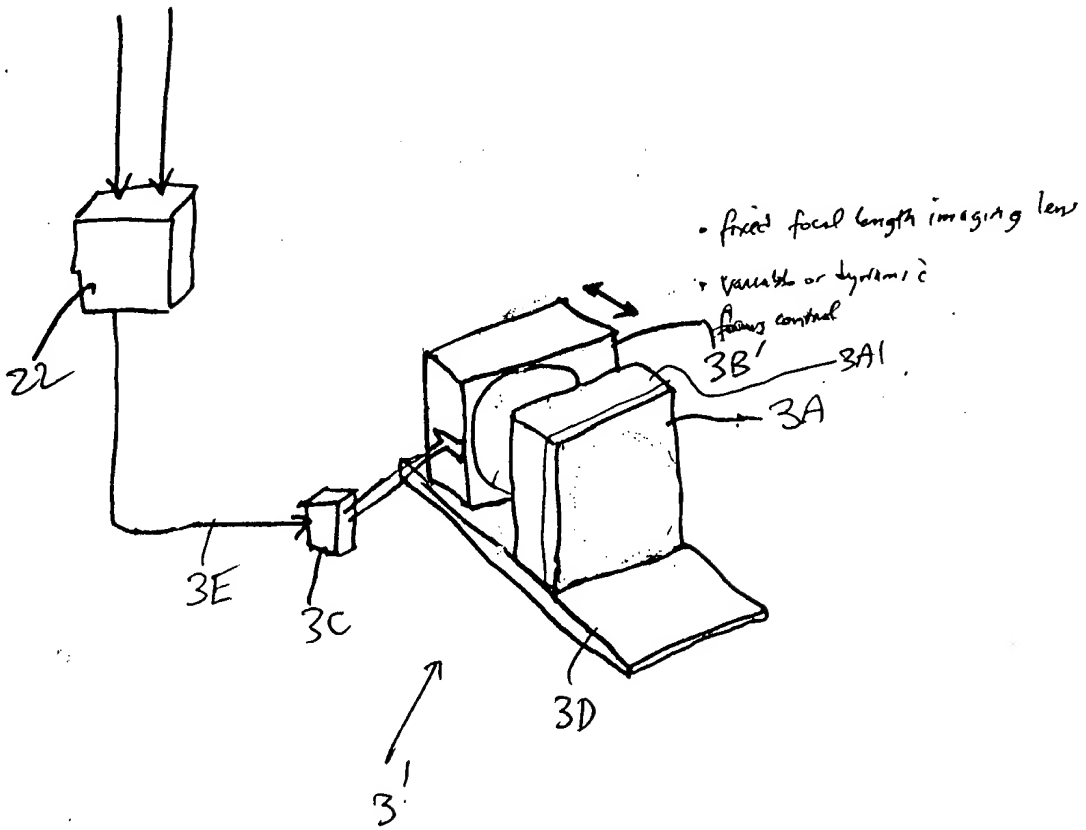

• fixed focal length imaging lens
• variable or dynamic focus control
22
3B'
3A1
3A
3E
3C
3D
3'

FIG. 2I4

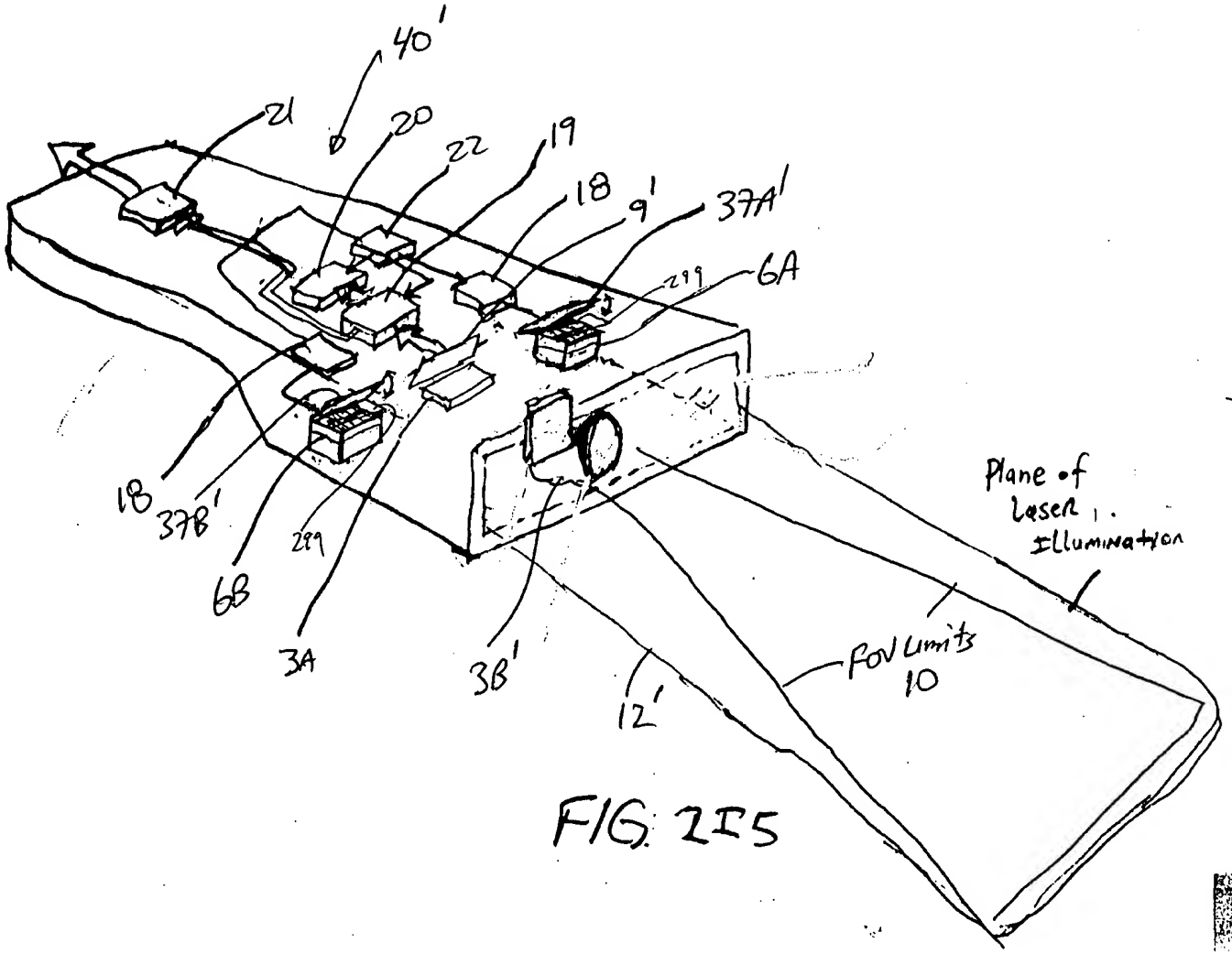

40'
21
20
22
19
18
9'
37A'
6A
29'
18
37B'
6B
29'
3A
3B'
12'
Plane of Laser Illumination
FOV Limits
10

FIG. 2I5

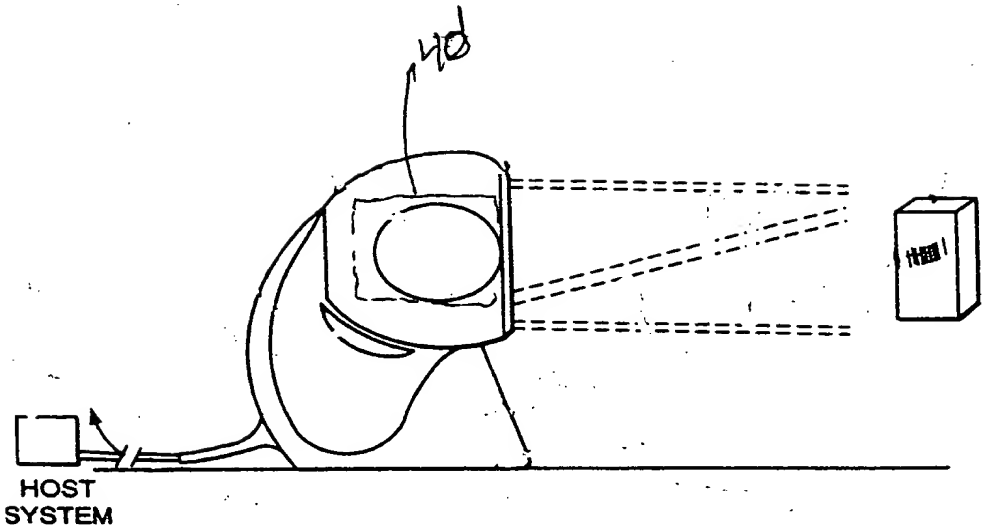


FIG. 2I6

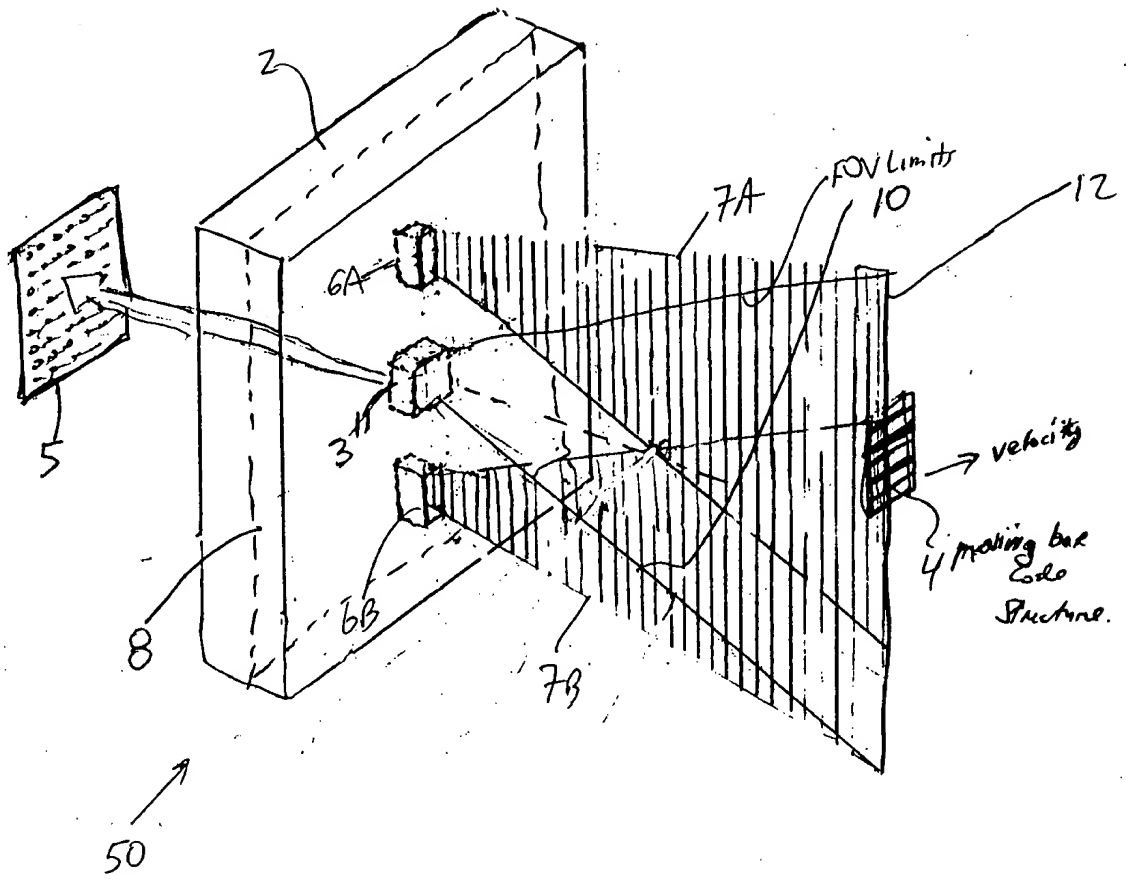

2
7A
FOV Limits
10
12
6A
5
3
velocity
4 mating bar Code Structure.
8
6B
7B
50

FIG 3A

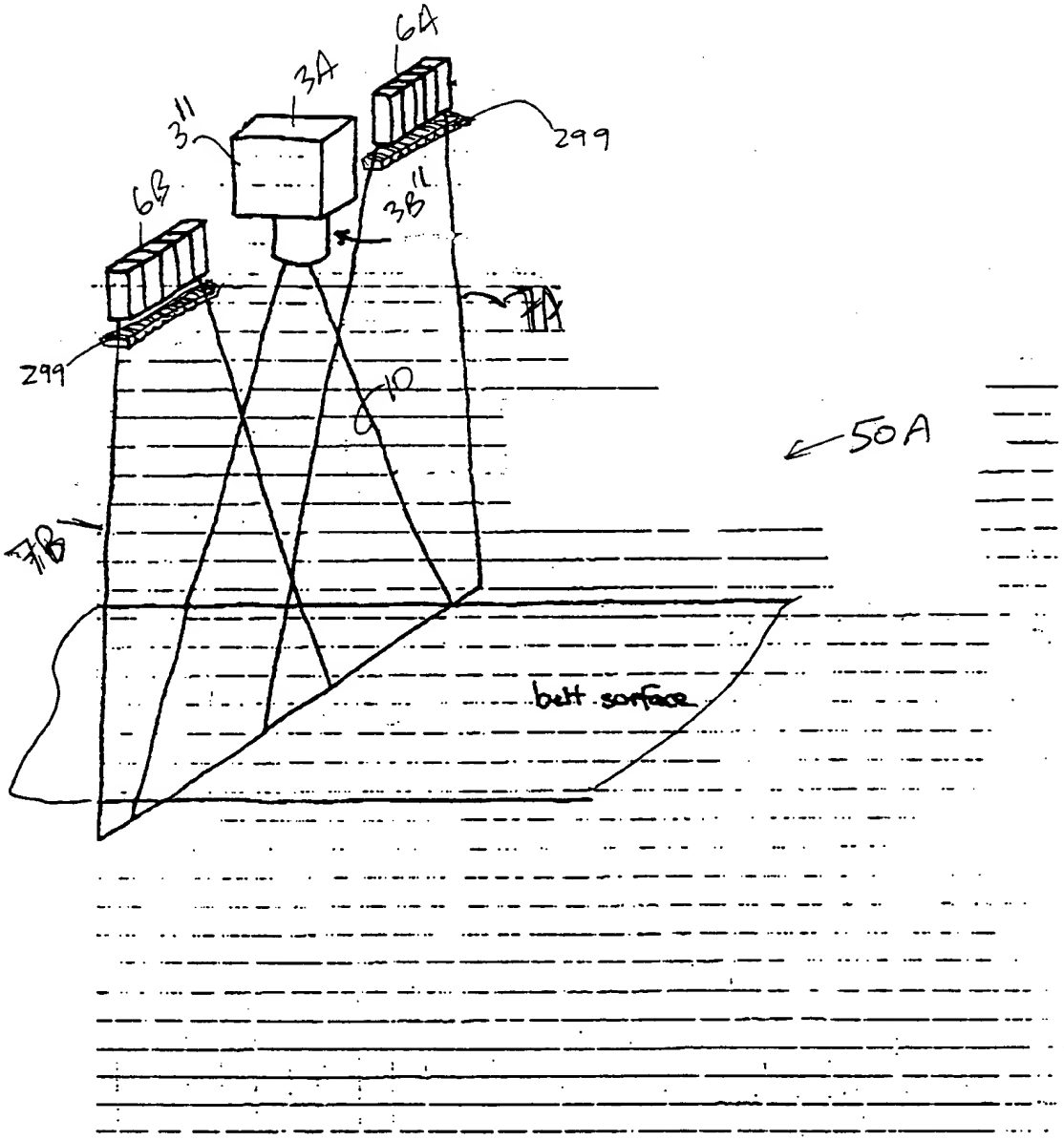


FIG. 3B1

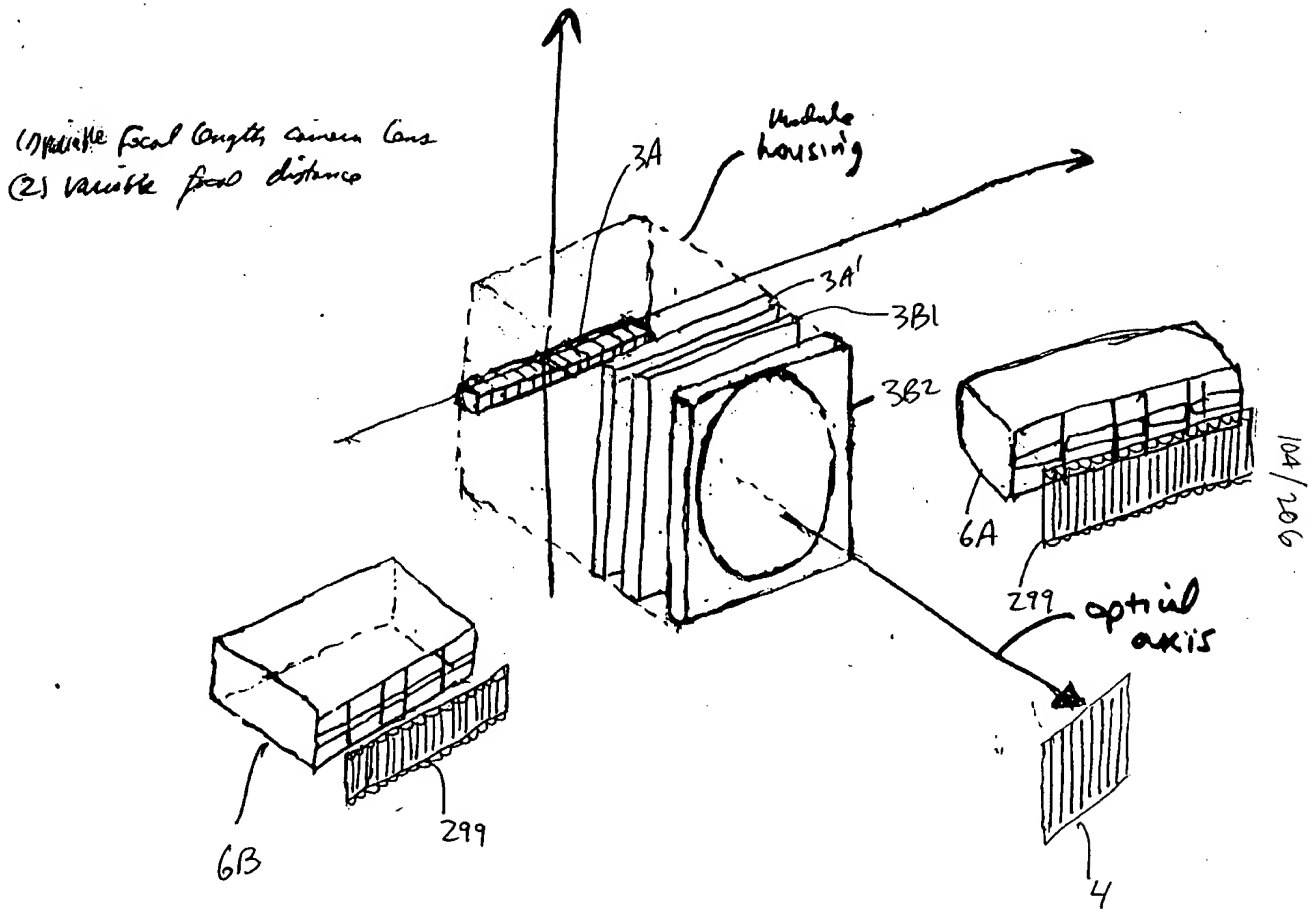

(1) Variable Focal Length camera Lens
(2) variable focal distance
3A
Module housing
3A'
3B1
3B2
6A
299
optical axis
101/206
6B
299
4

FIG. 3B2

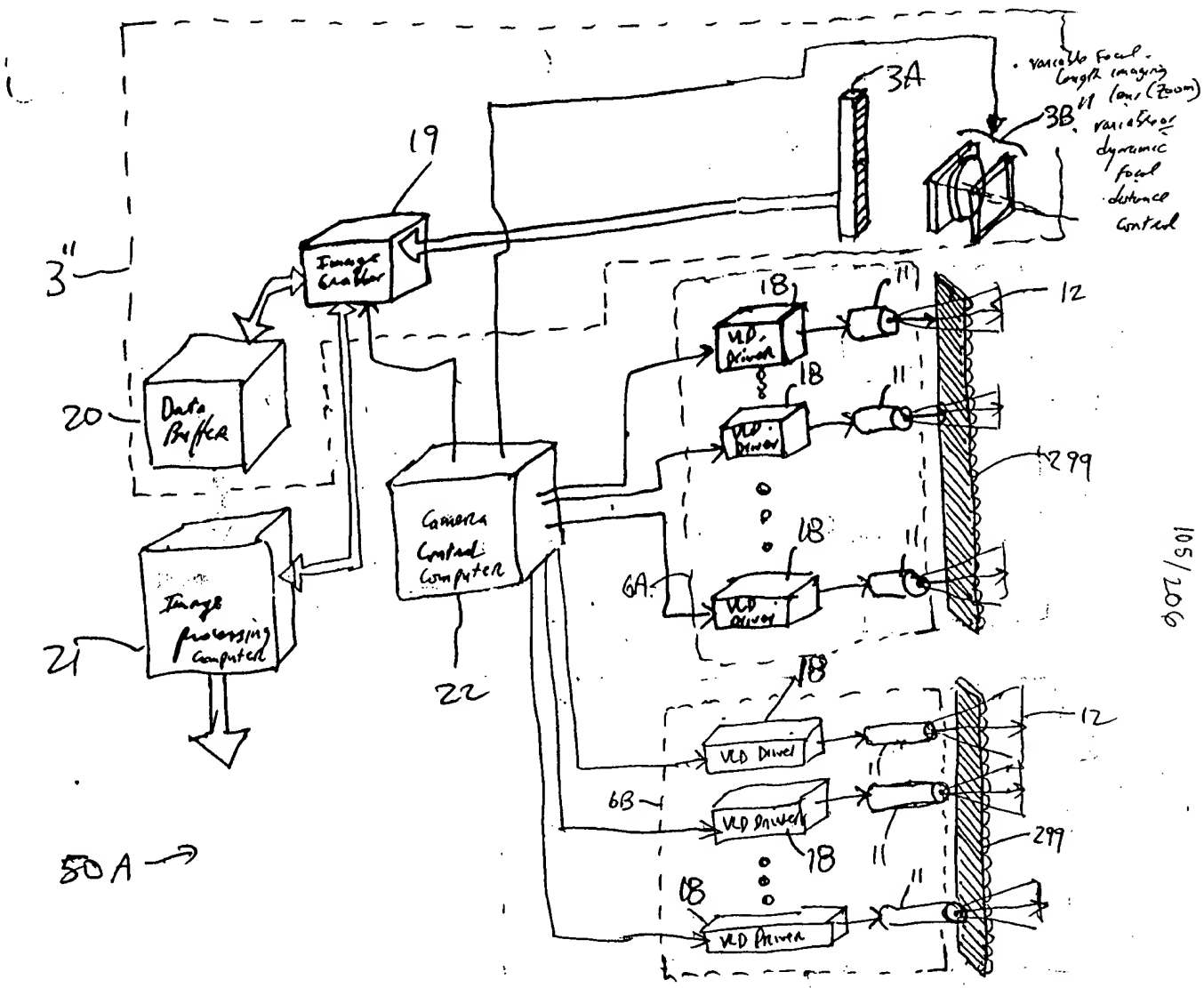

3A
variable focal length imaging lens (zoom)
3B
variable dynamic focal distance control
19
3"
Image Controller
20
Data Buffer
21
Image processing Computer
Camera Control Computer
22
18
11
12
299
6A
6B
VLD Driver
50A

FIG 3C1

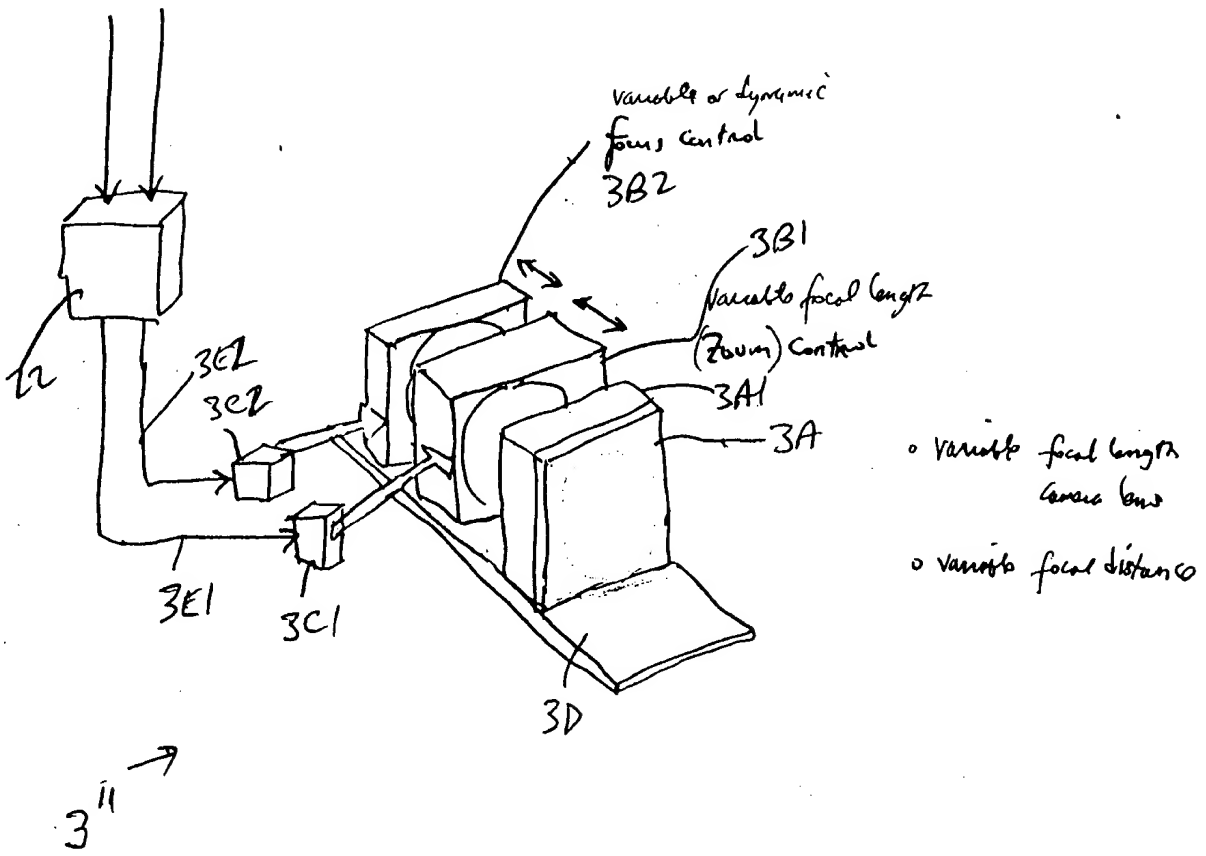

variable or dynamic
focus control
3B2
3B1
variable focal length
(zoom) control
3A1
3A
3E2
3C2
3E1
3C1
3D
3''
• variable focal length camera lens
• variable focal distance

FIG. 3C2

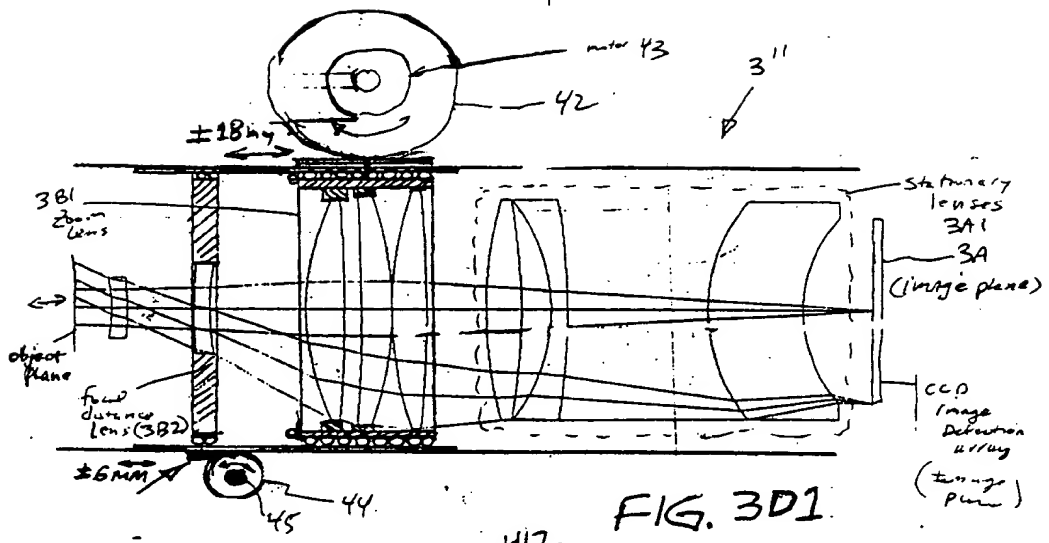


FIG. 3D1

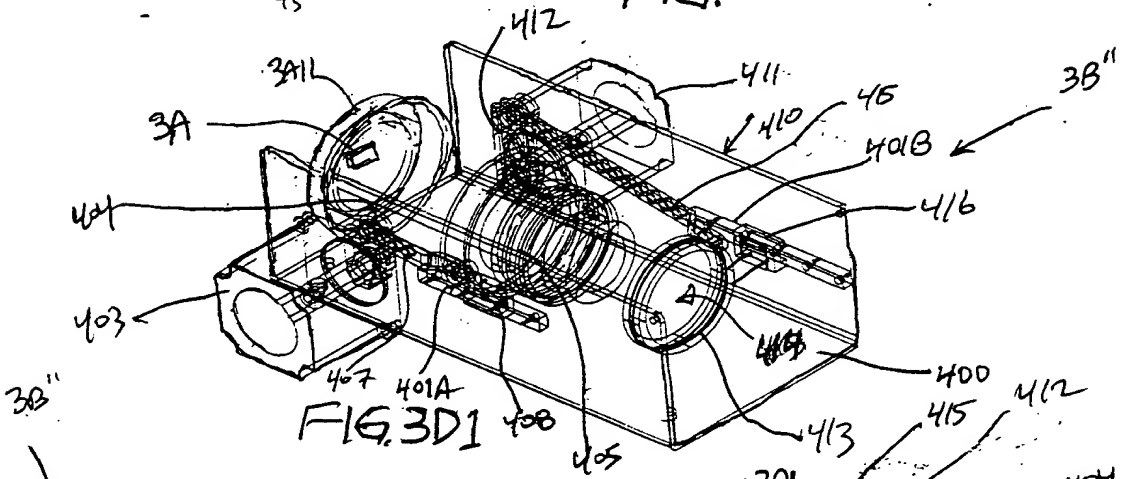


FIG. 3D1

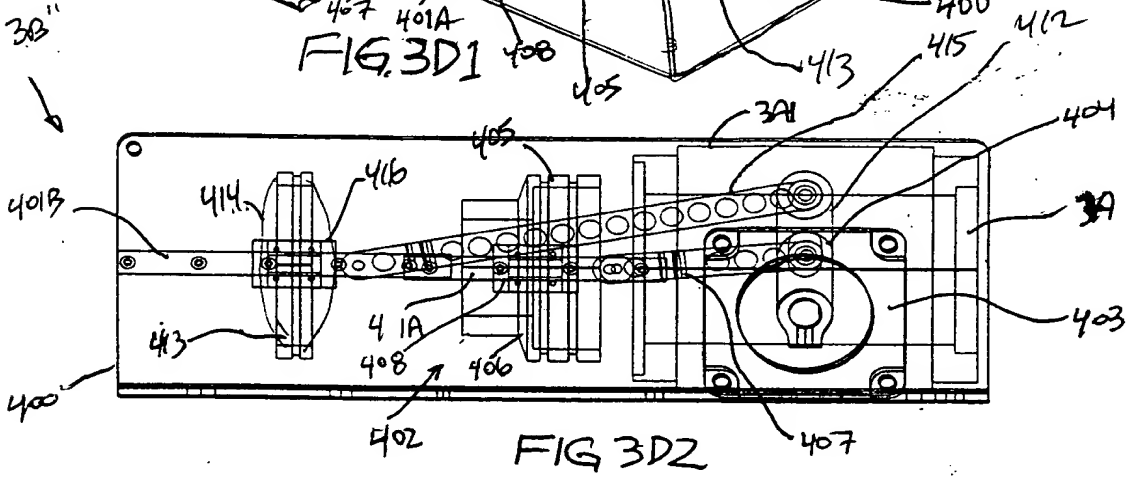


FIG 3D2

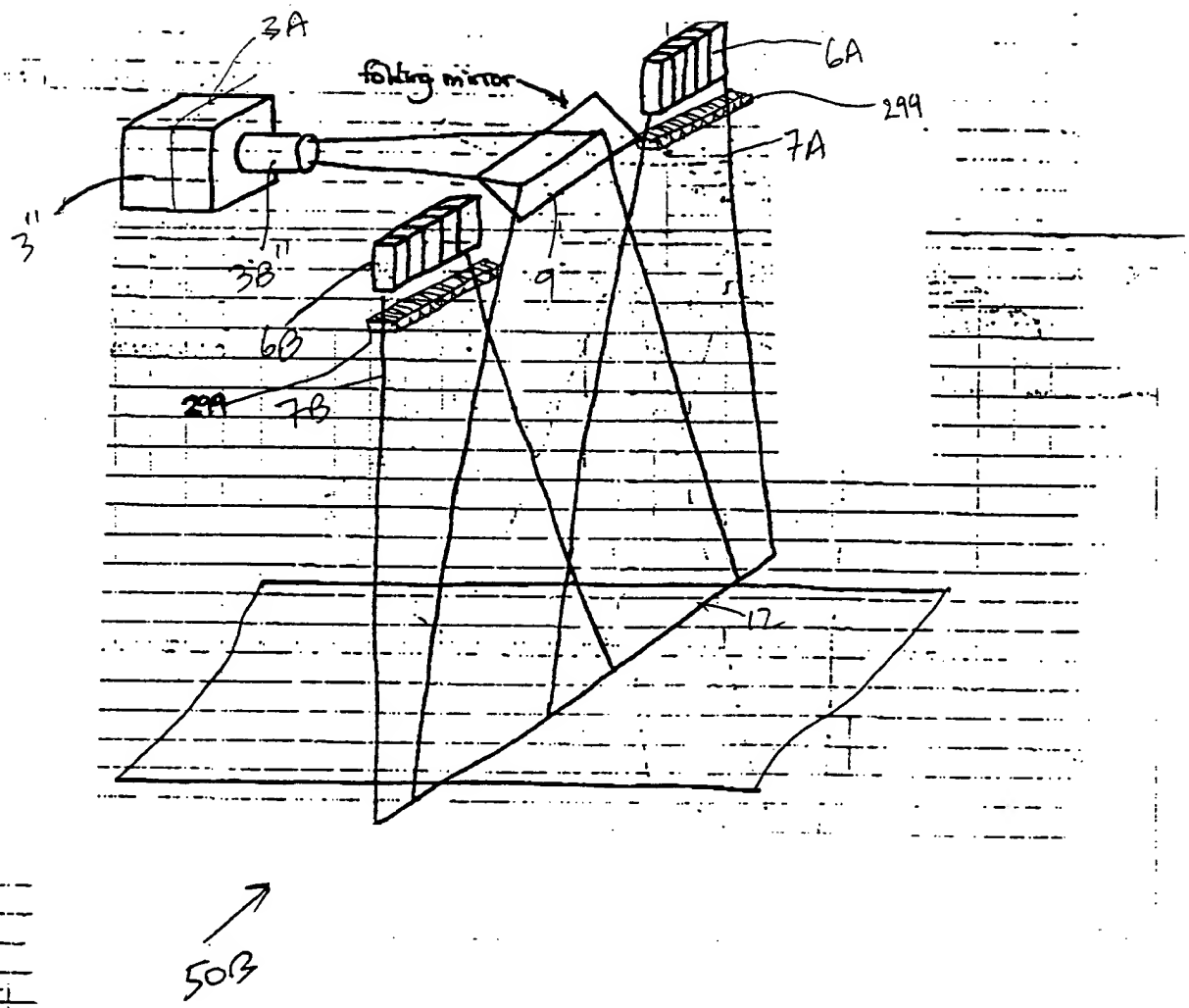


FIG 3E1

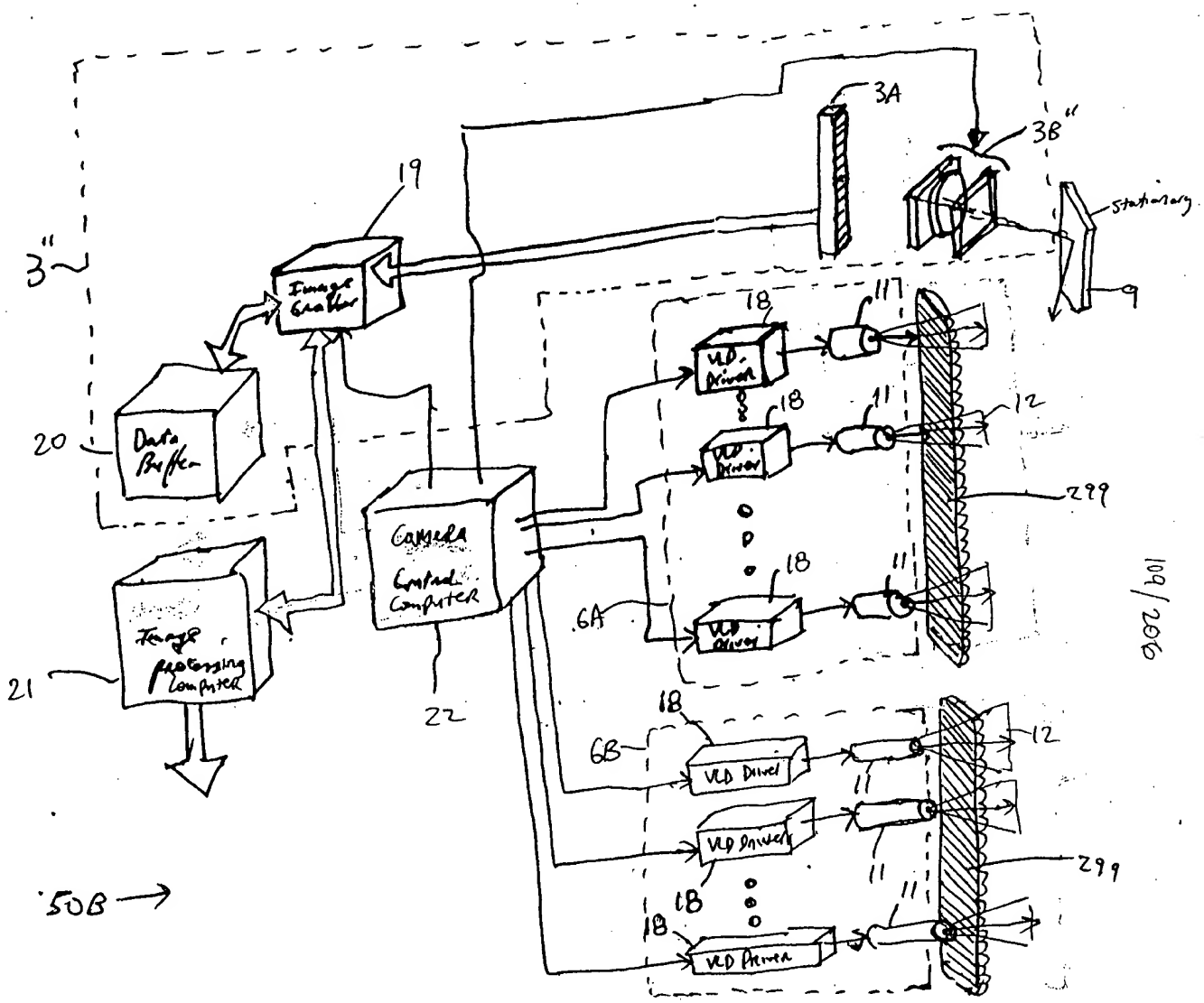


FIG. 3E2

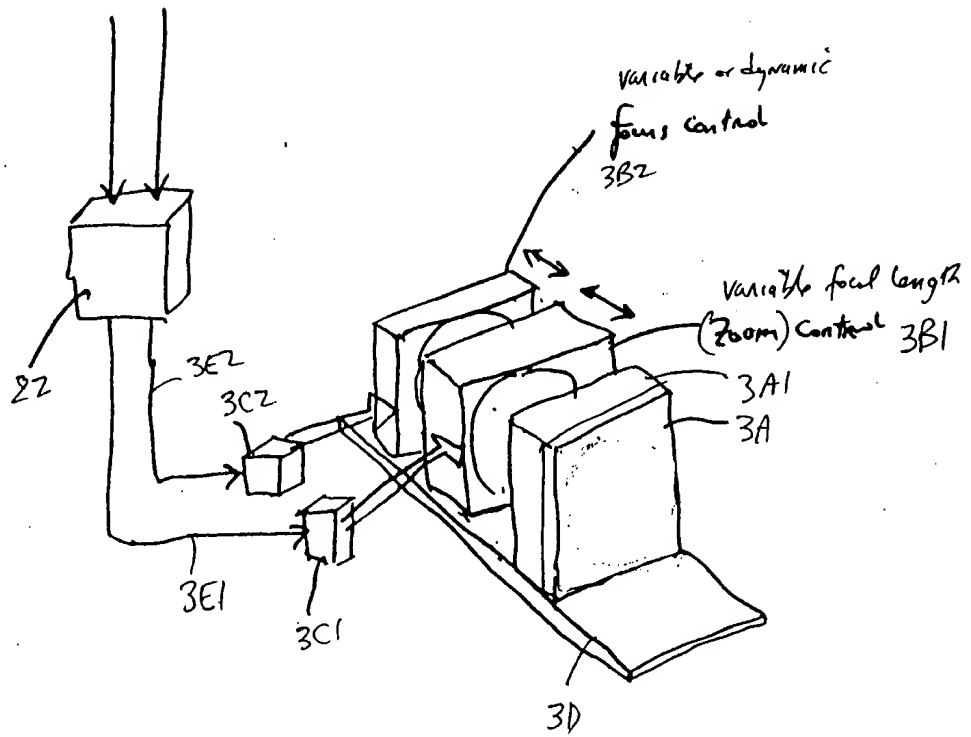


FIG. 3E3

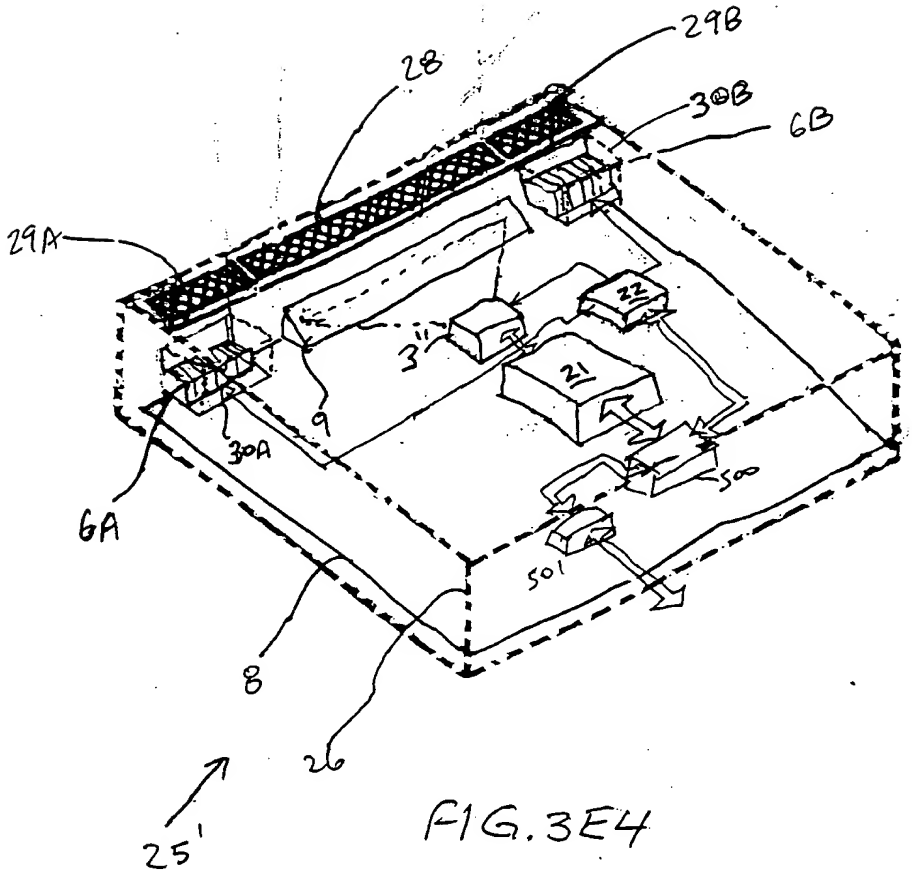


FIG. 3E4

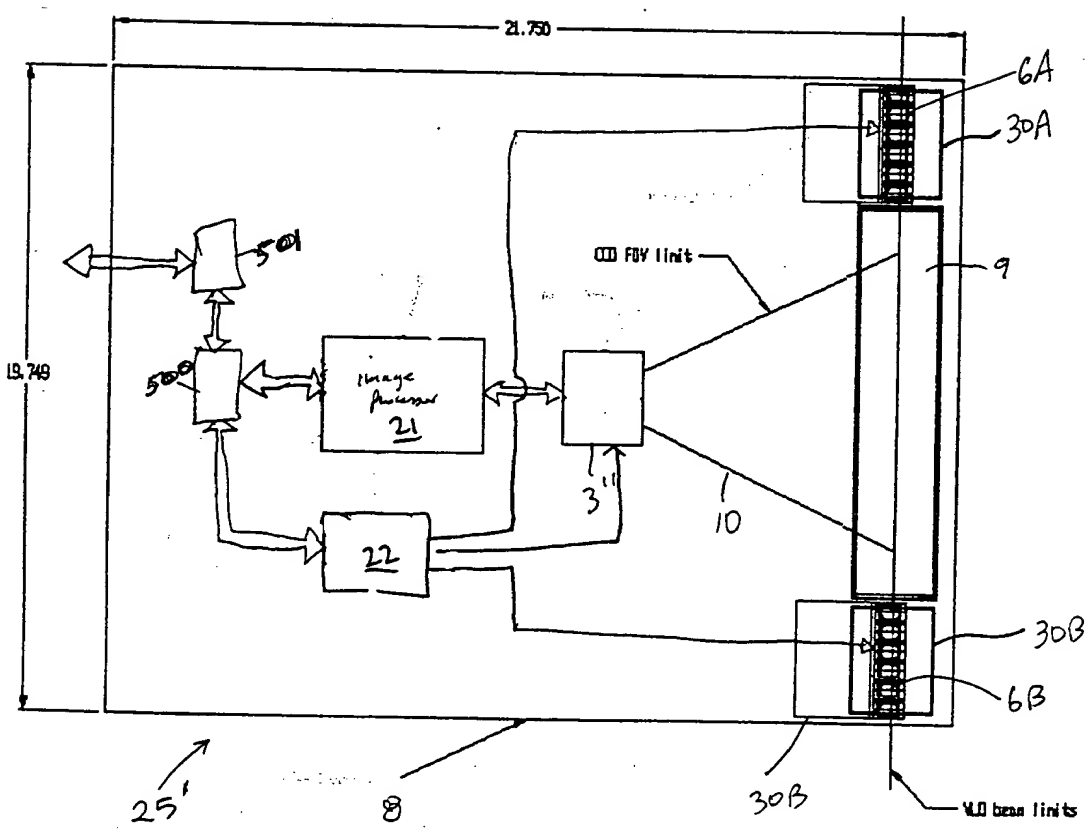

21.750
19.749
6A
30A
CCD FOV limit
9
501
500
Image Processor
21
3
10
22
30B
6B
25
8
30B
4.0 beam limits

FIG. 3E5

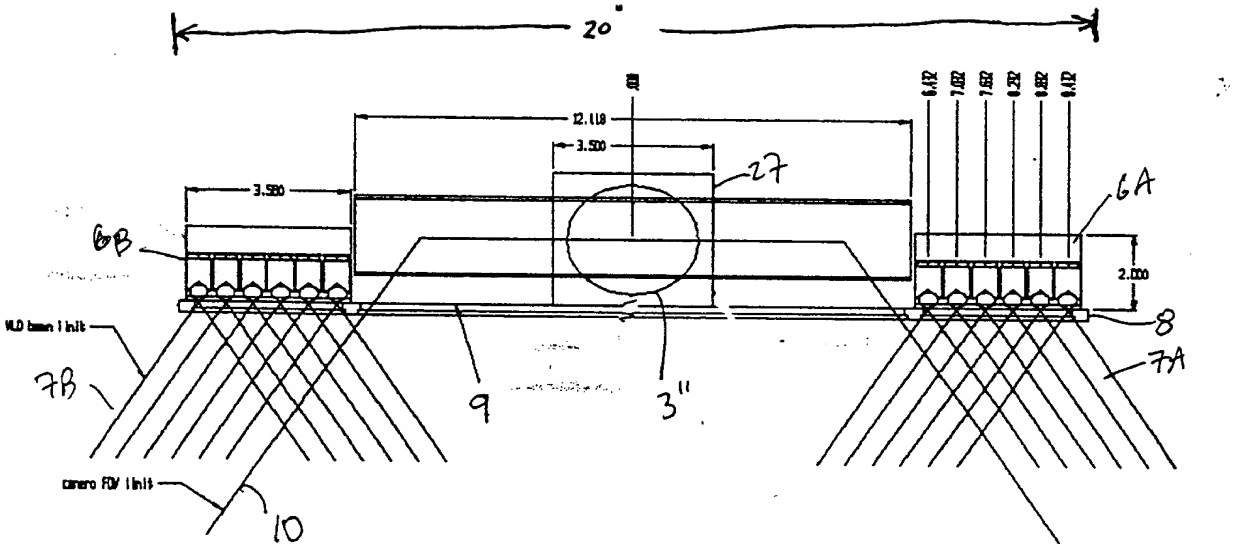


FIG. 3E6

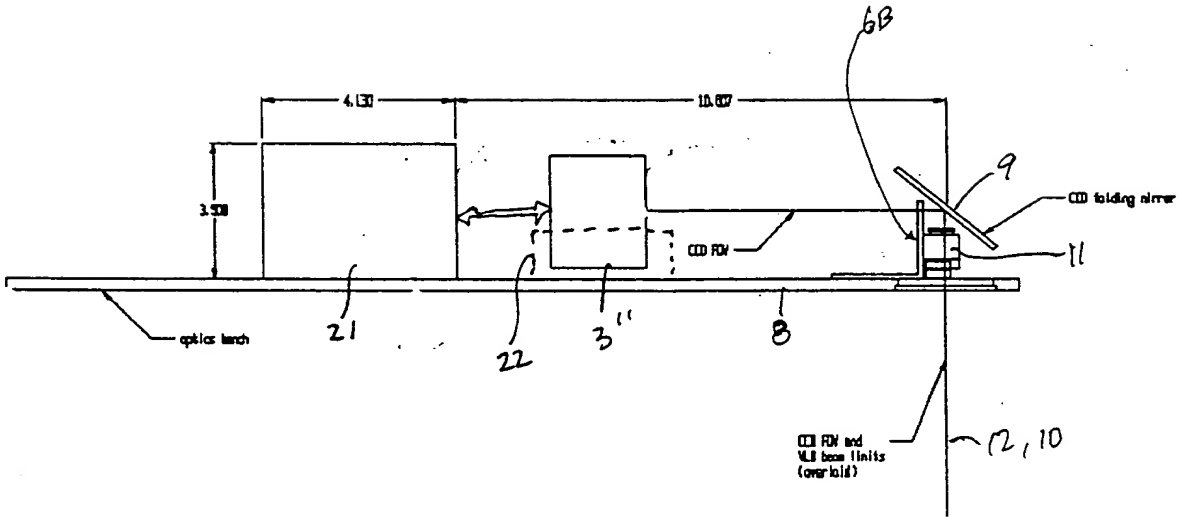

6B
4.130
10.607
3.500
9
CCD folding mirror
CCD FOV
11
optics bench
21
22
3''
8
CCD FOV and
VLS beam limits
(overlaid)
12, 10

FIG. 3E7

*variable FOV

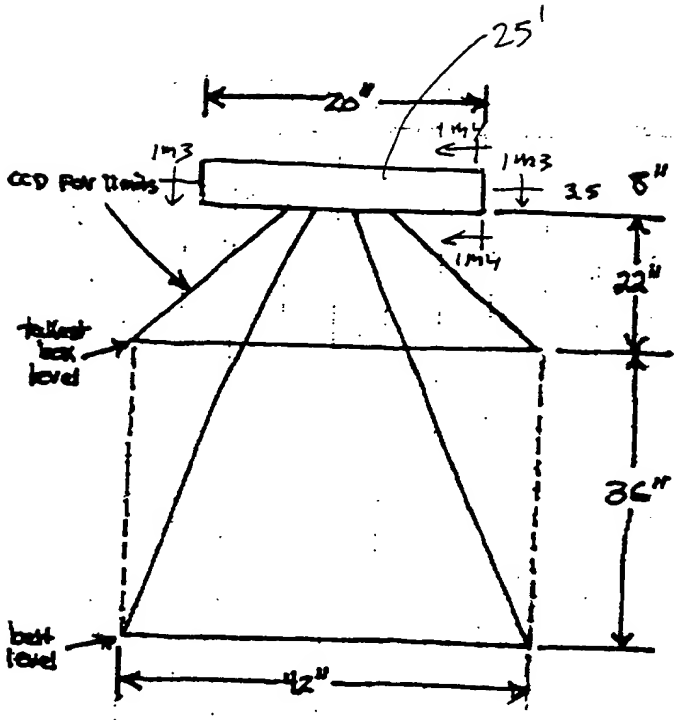


FIG. 3E8

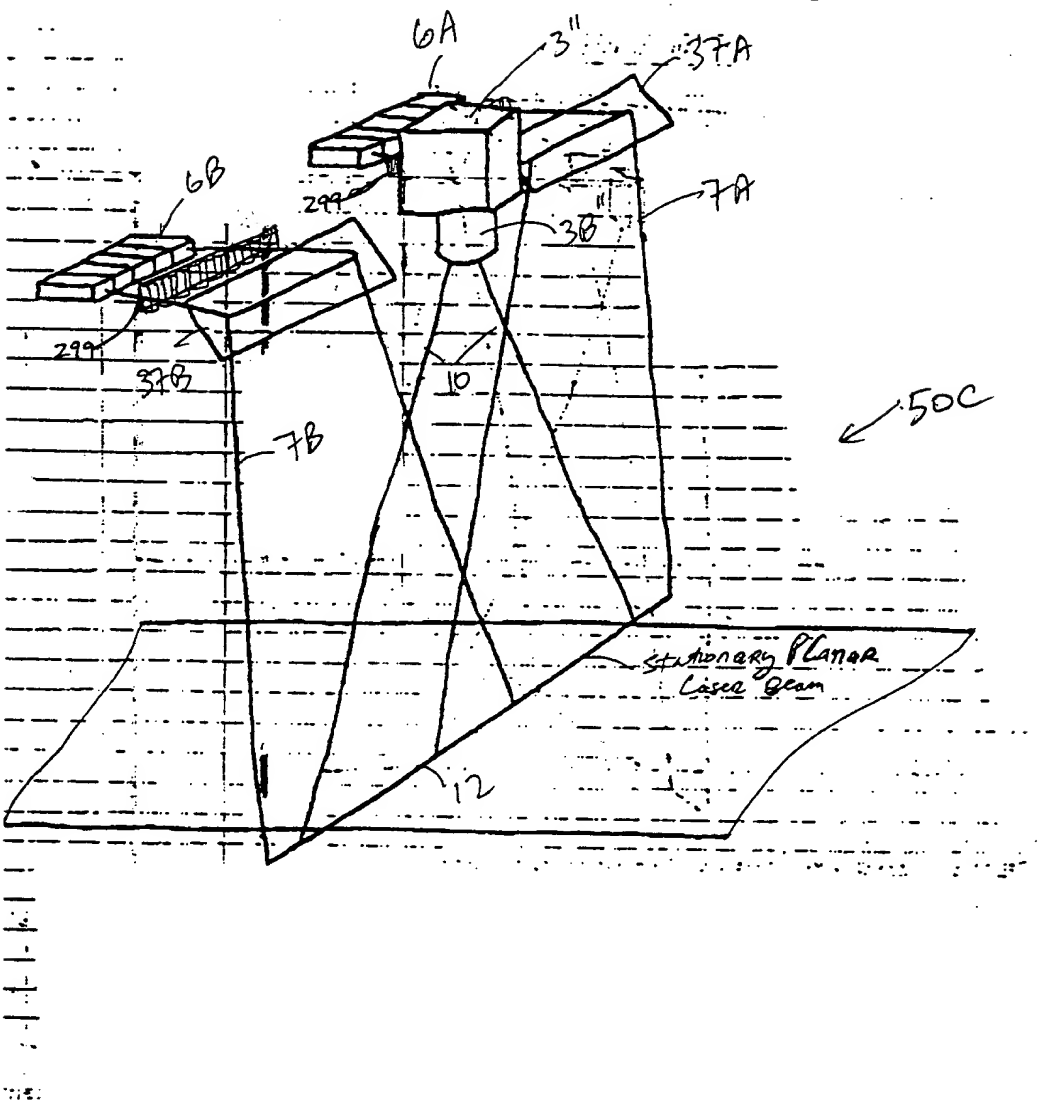

6A
3"
37A
6B
299
7A
3B
299
37B
10
50C
7B
Stationary Planar
Laser Beam
12

FIG. 3F1

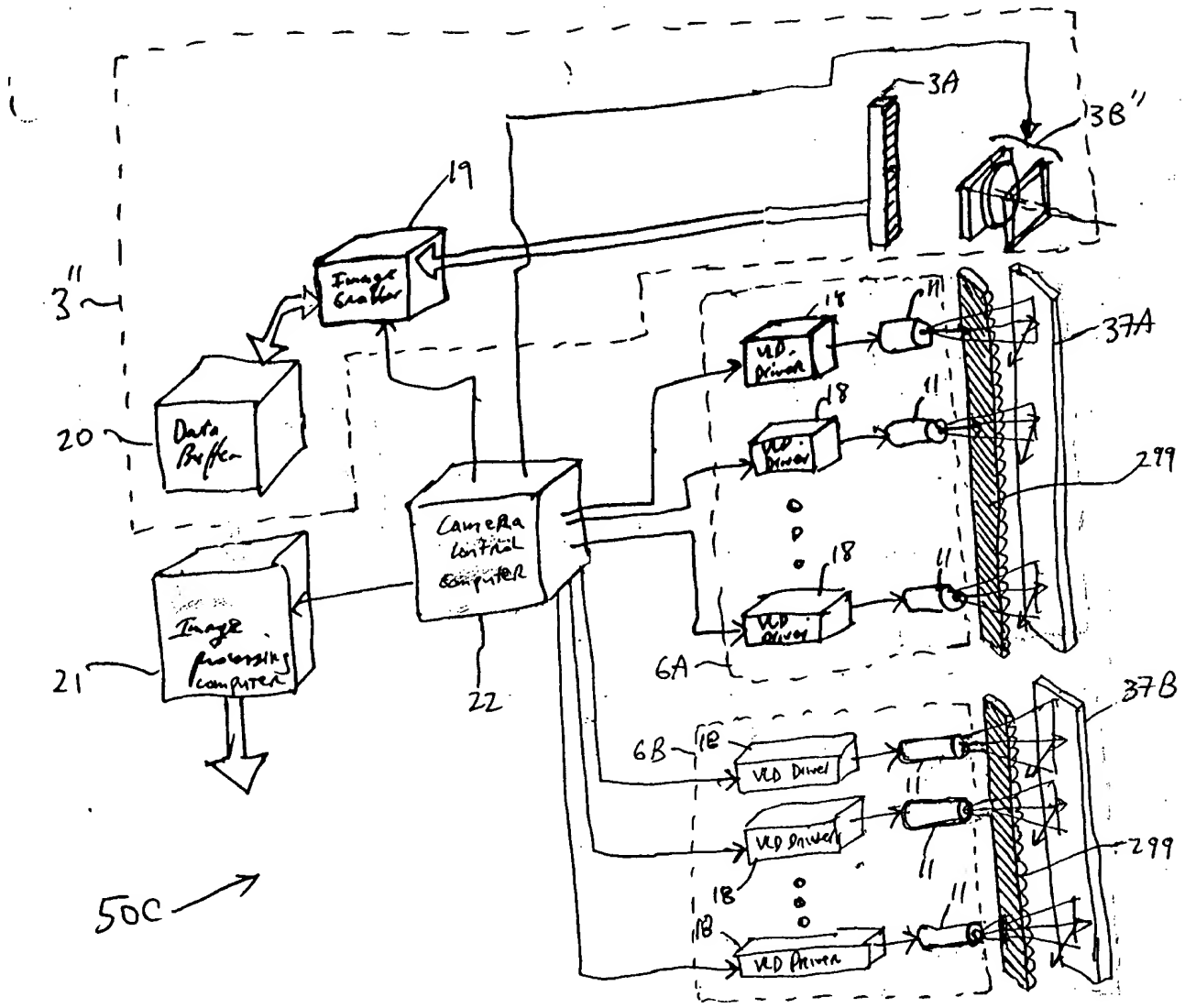

3A
3B"
19
3"
Image Grabber
20
Data Buffer
Camera Control Computer
Image Processing Computer
21
22
50C
VLD Driver
18
11
37A
299
6A
37B
6B

FIG. 3F2

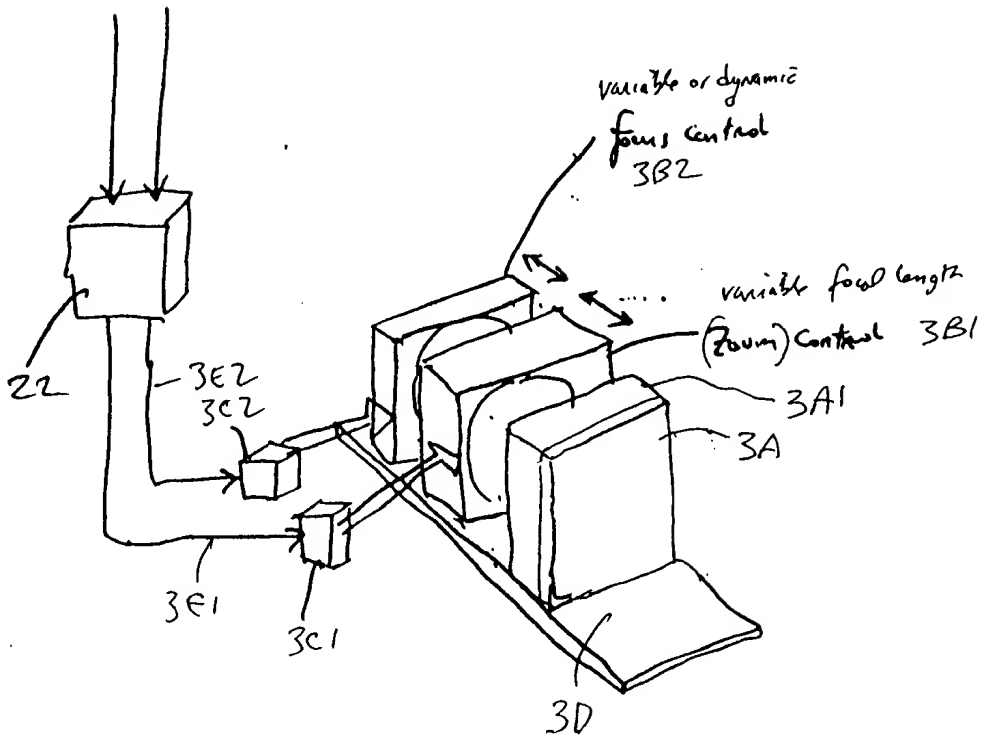


FIG. 3F3

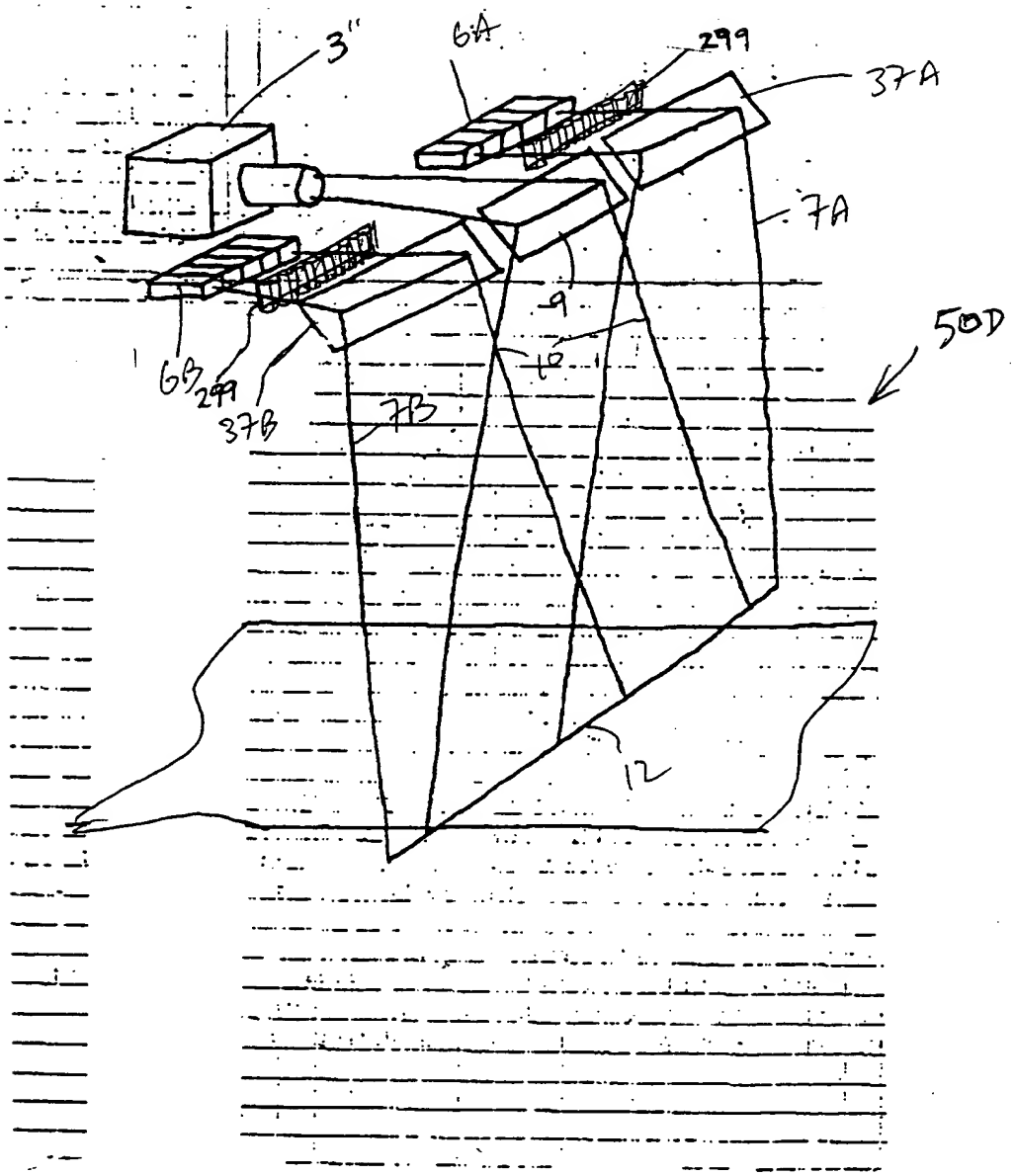


FIG. 36I

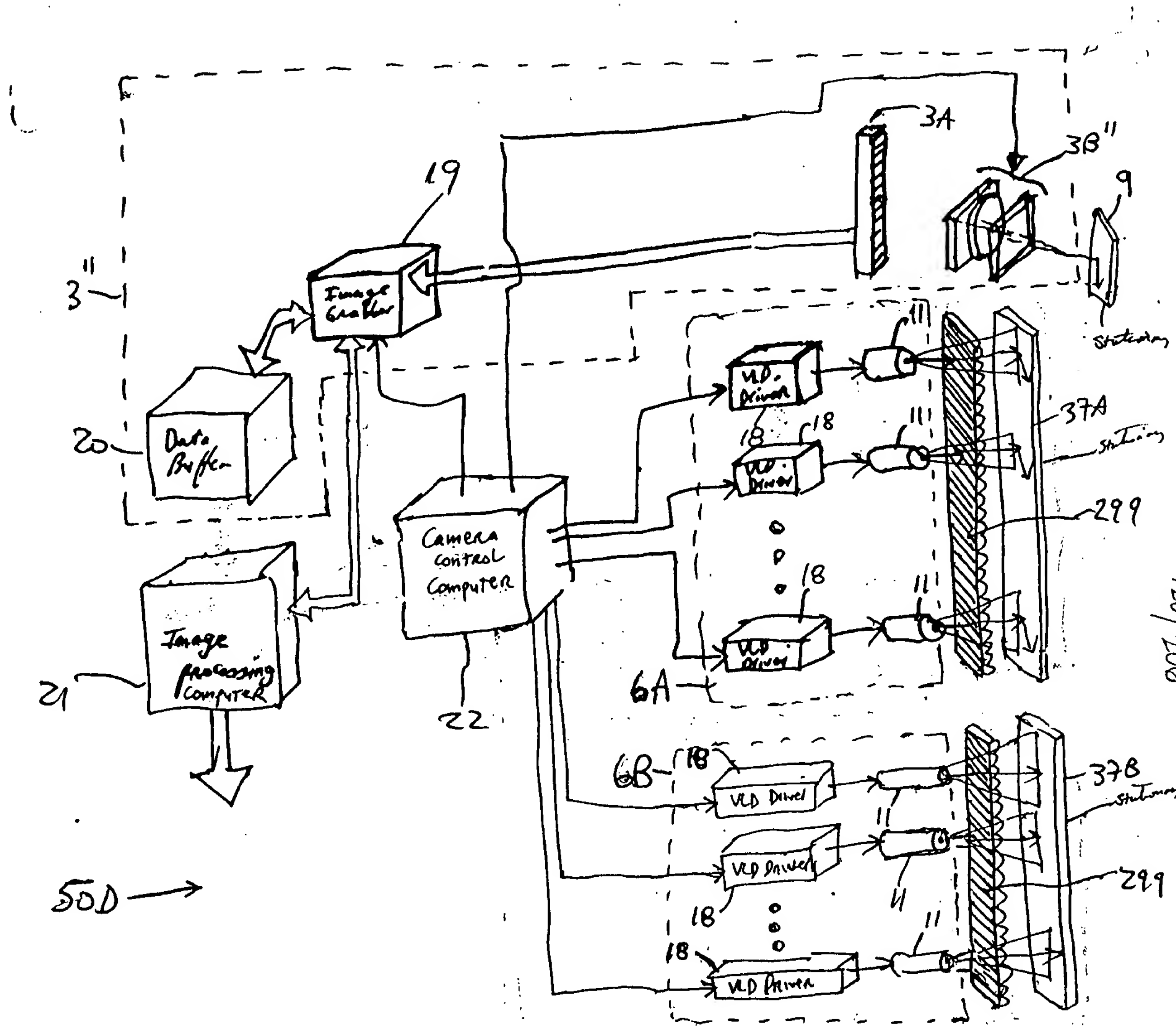

3A
3B"
9
Stationary
19
Image Grabber
3"
20
Data Buffer
21
Image processing Computer
Camera control Computer
22
VLD Driver
18
11
37A
Stationary
299
6A
6B
VLD Driver
37B
Stationary
299
50D

FIG. 3G2

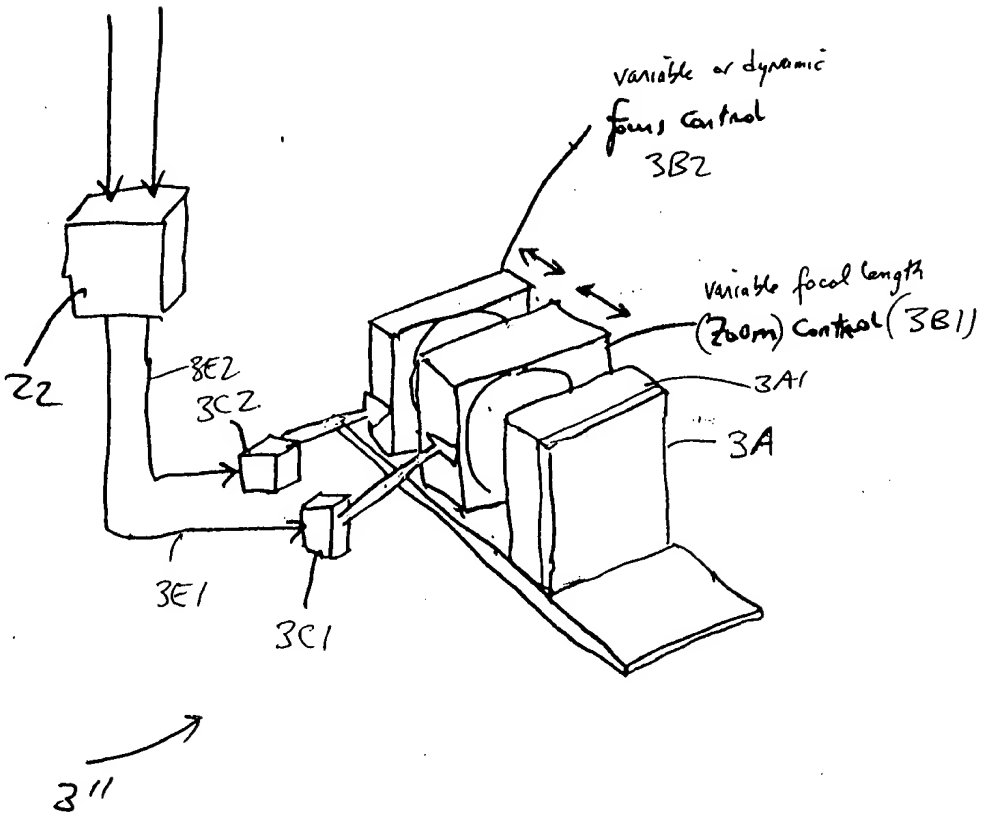

variable or dynamic
focus control
3B2
variable focal length
(Zoom) control (3B1)
3A1
3A
8E2
3C2
Z2
3E1
3C1
311

FIG. 3G3

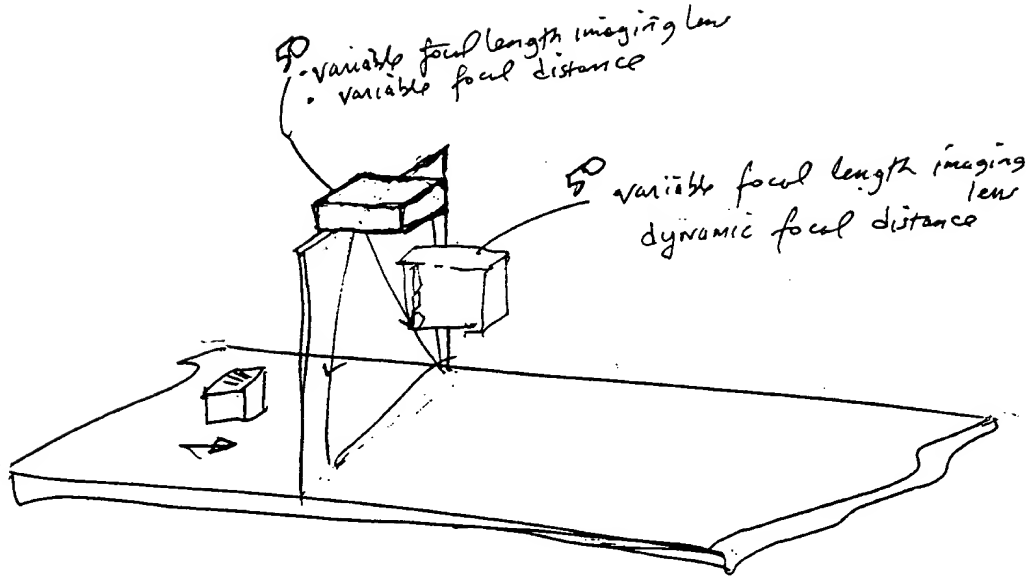

variable focal length imaging lens
• variable focal distance
variable focal length imaging lens
dynamic focal distance

FIG. 3H

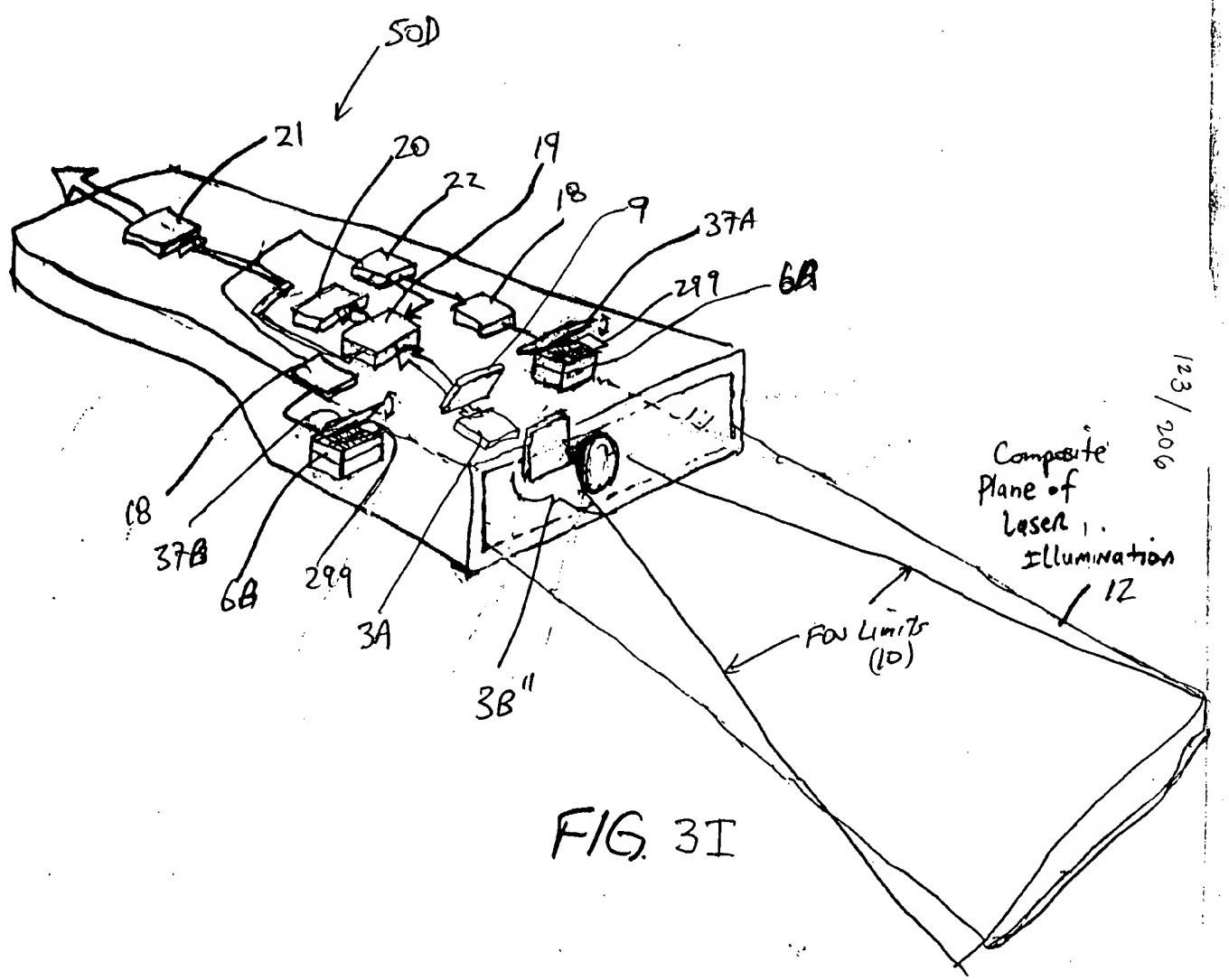


FIG. 3I

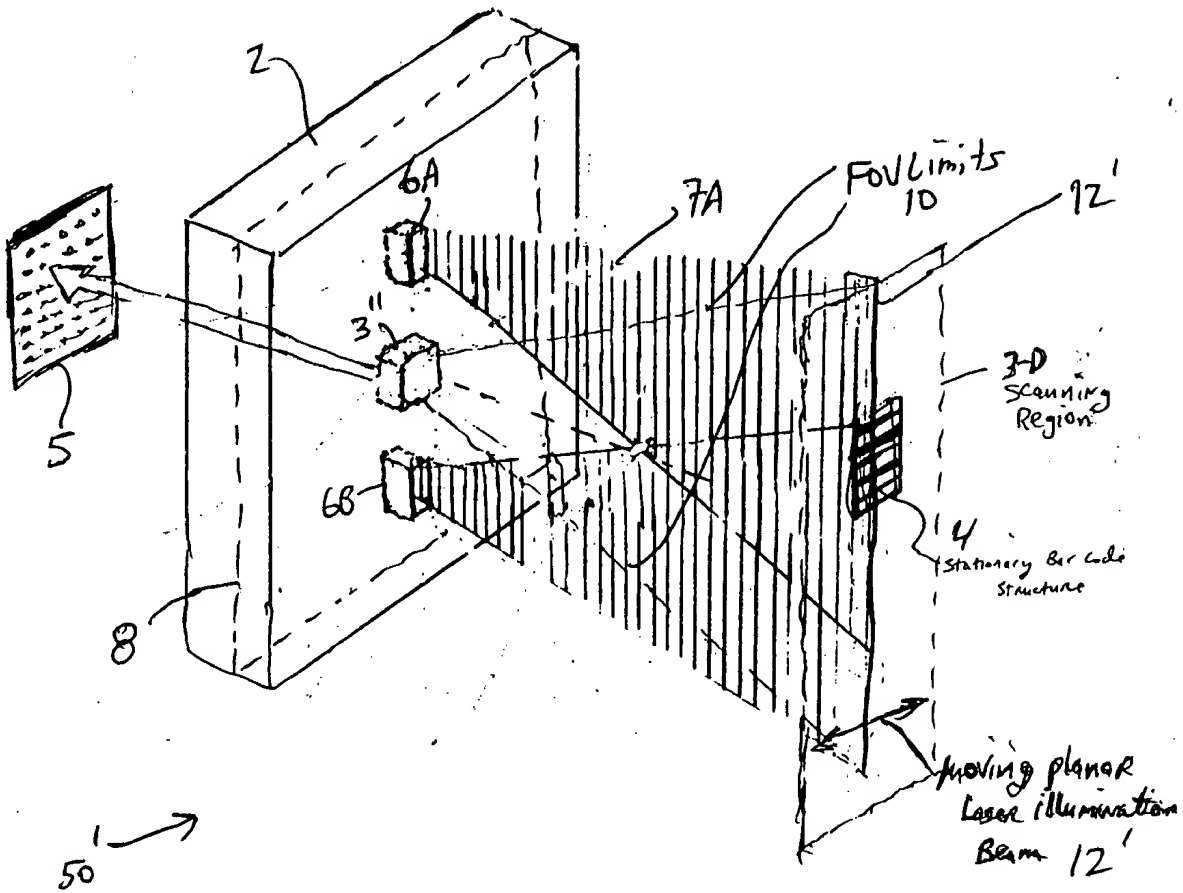

2
6A
7A
FOV Limits
10
12'
3"
3-D
Scanning
Region
5
6B
4
Stationary Bar Code
Structure
8
Moving planar
Laser illumination
Beam 12'
1
50

FIG. 3J1

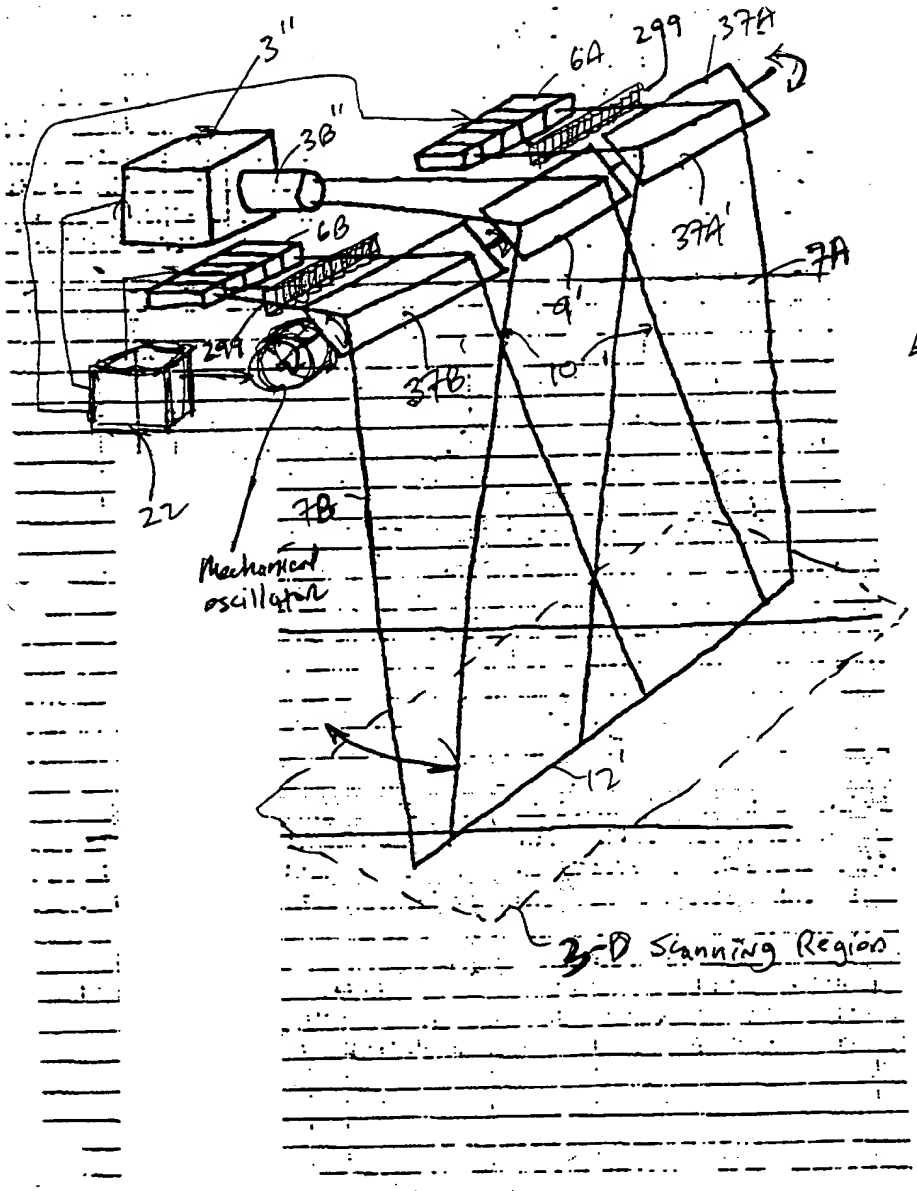

3''
6A
299
37A
38''
6B
37A'
7A
50'
9'
10'
37B
22
7B
Mechanical oscillator
12'
3-D Scanning Region

FIG. 3J2

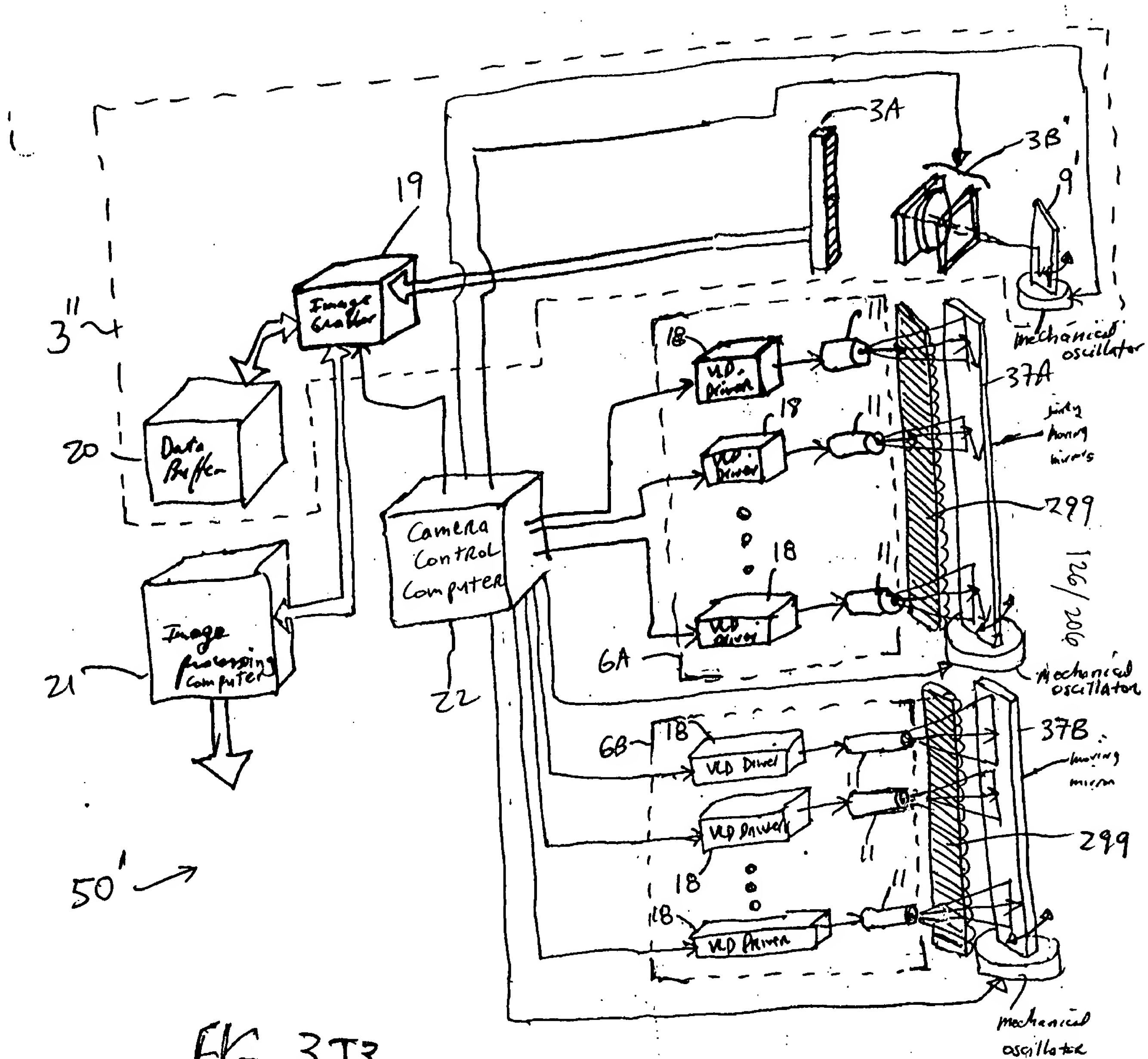


FIG. 3J3

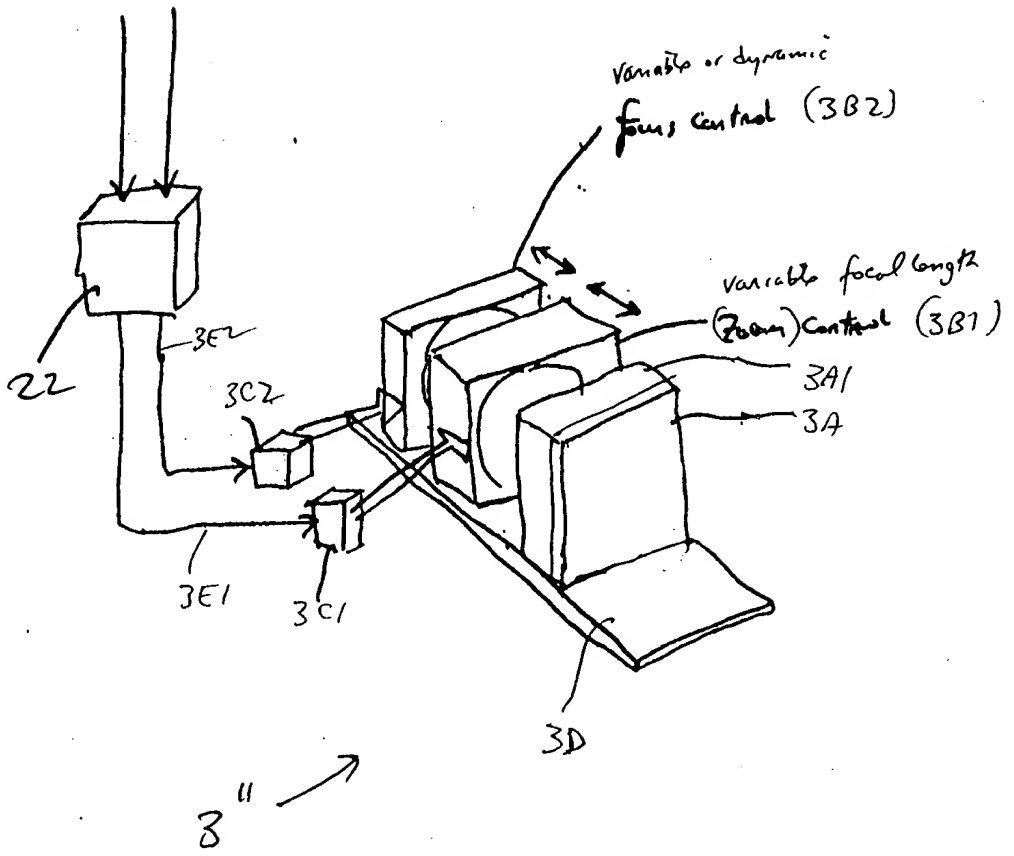


FIG. 3J4

12/1/206

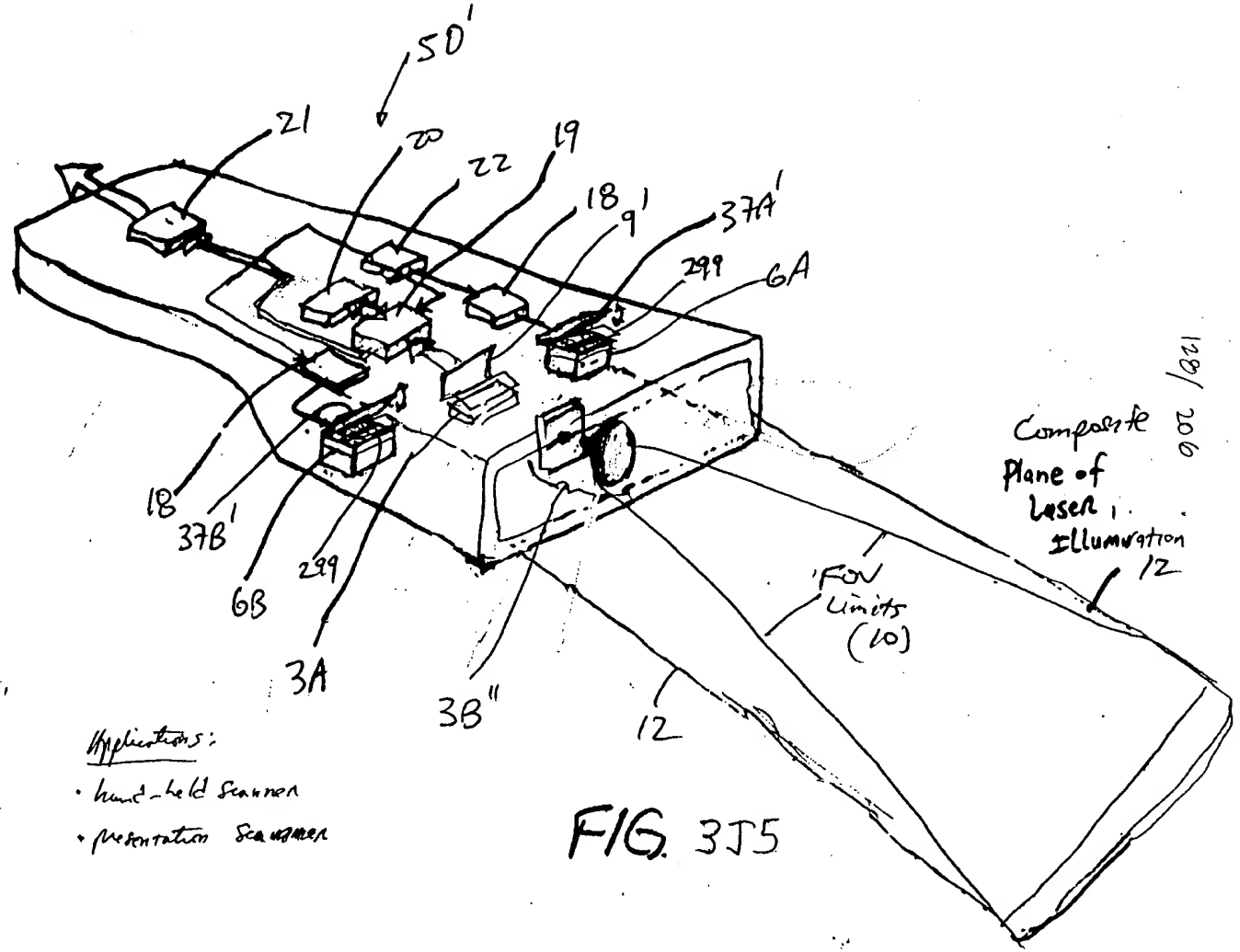

50'
21
20
22
19
18
9'
37A'
299
6A
18
37B'
6B
299
3A
3B"
12
Composite
Plane of
Laser
Illumination
12
FOV
Limits
(10)
120/206
Applications:
• hand-held scanner
• presentation scanner

FIG. 3J5

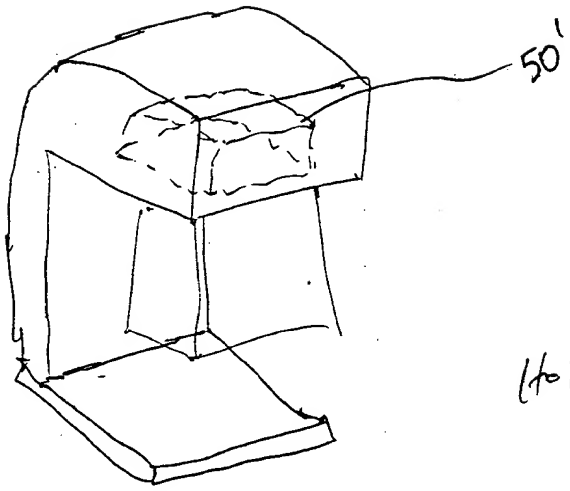


FIG-3J6

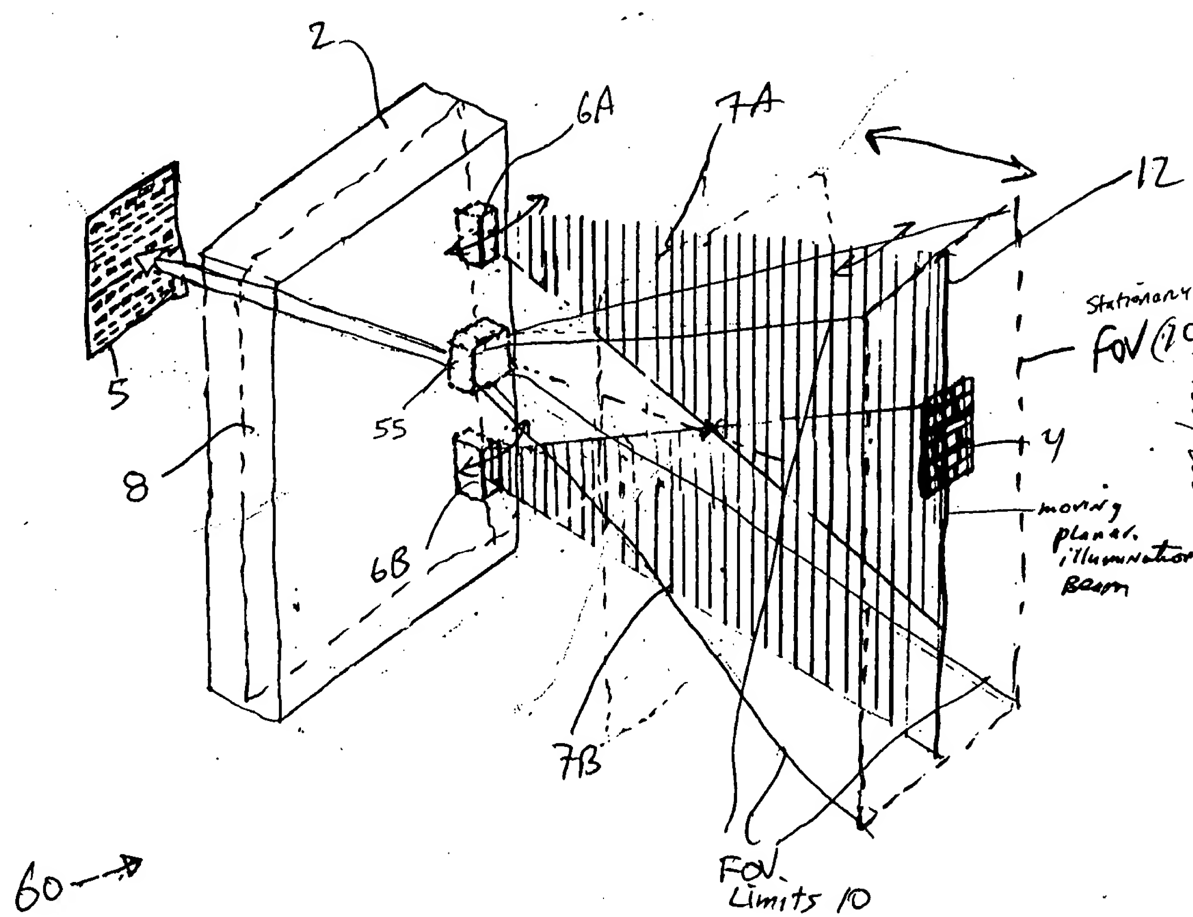


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FIG 4A

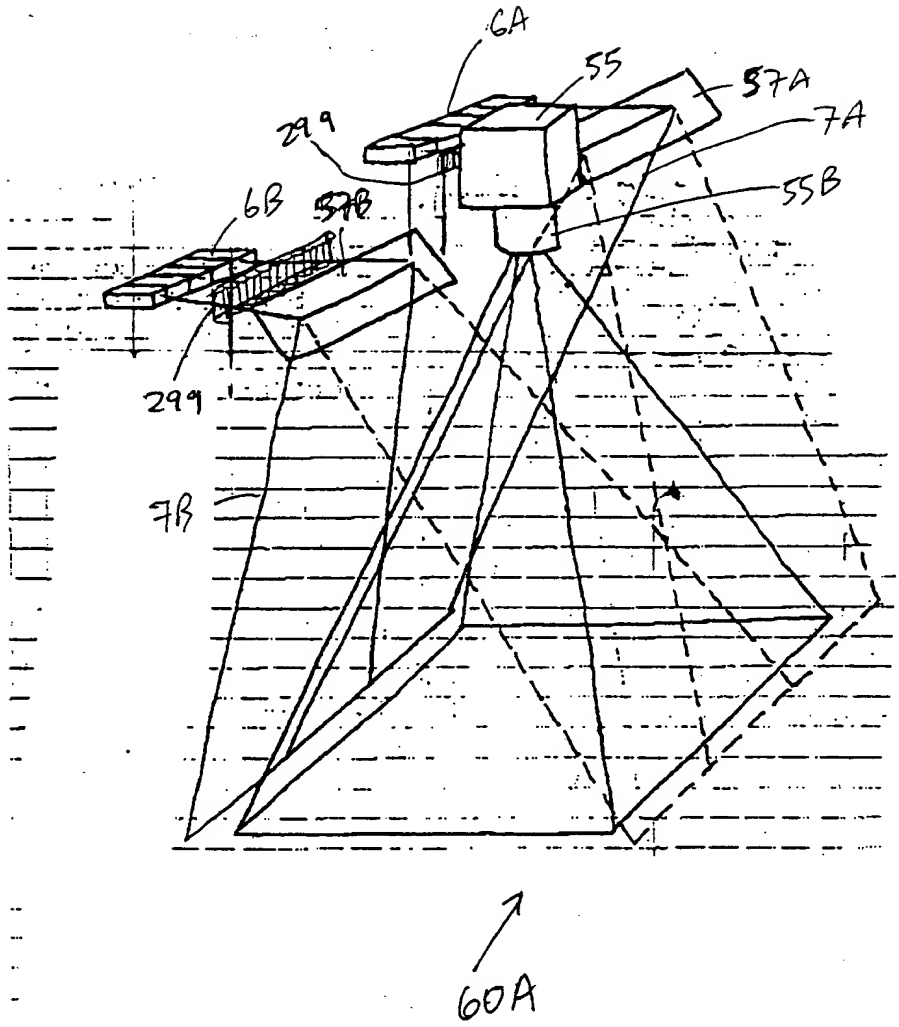


FIG. 4B1

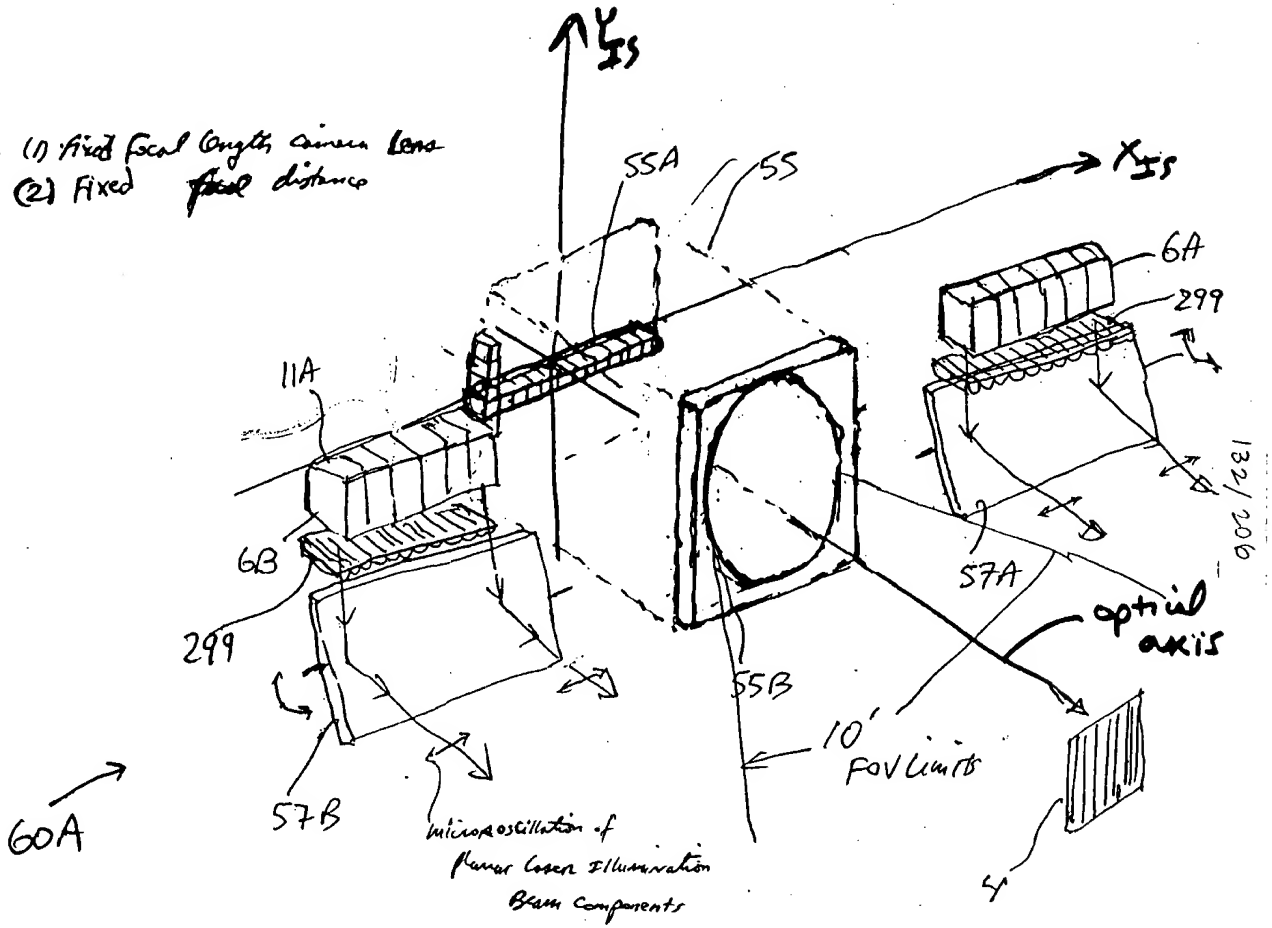


FIG. 4B 2

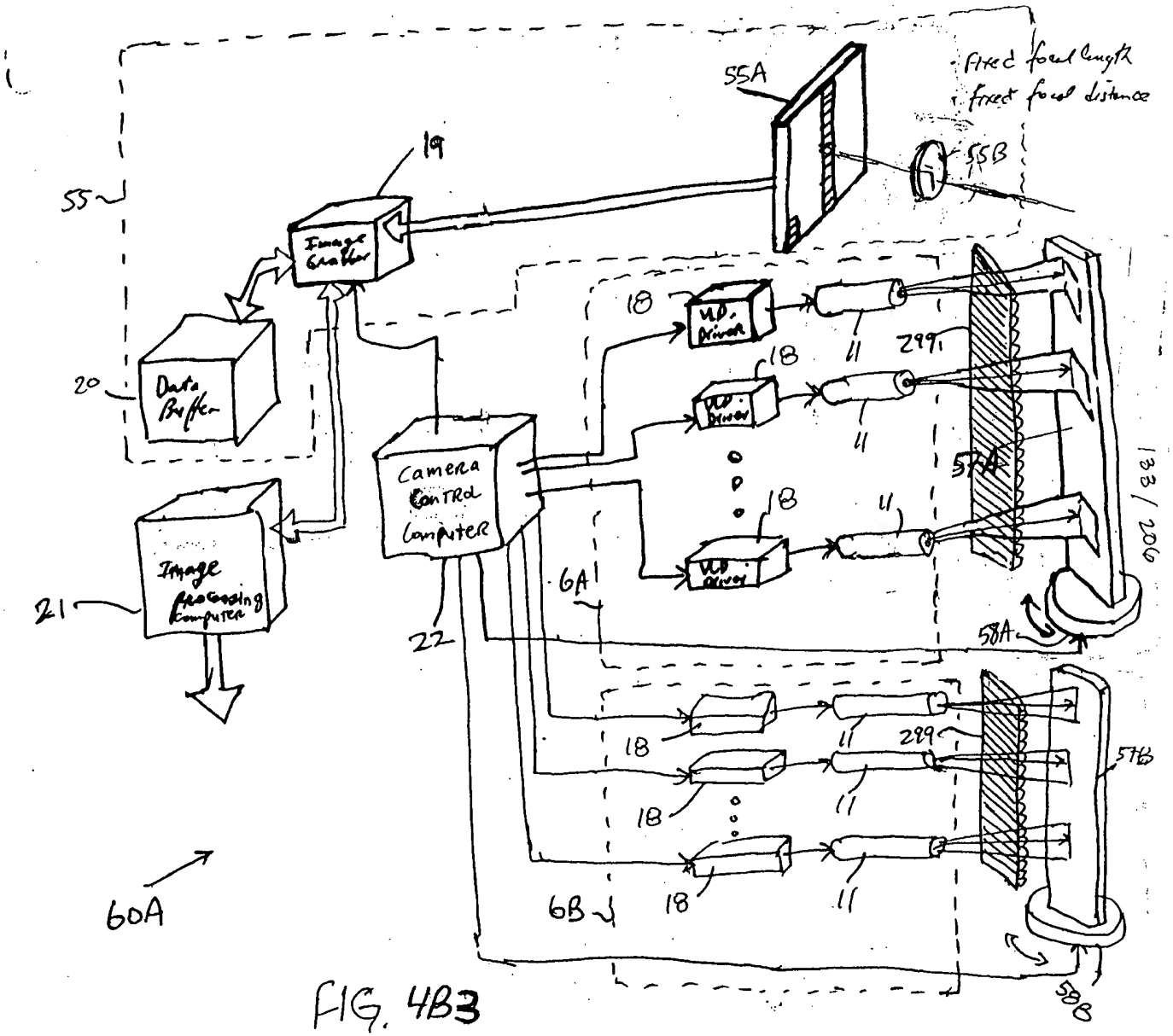

55A
fixed focal length
fixed focal distance
55B
19
55
Image Grabber
18
VLD Driver
11
299
18
VLD Driver
11
20
Data Buffer
Camera Control Computer
57A
18
VLD Driver
11
133/206
6A
58A
21
Image Processing Computer
22
18
11
299
57B
18
11
18
11
6B
58B
60A

FIG. 4B3

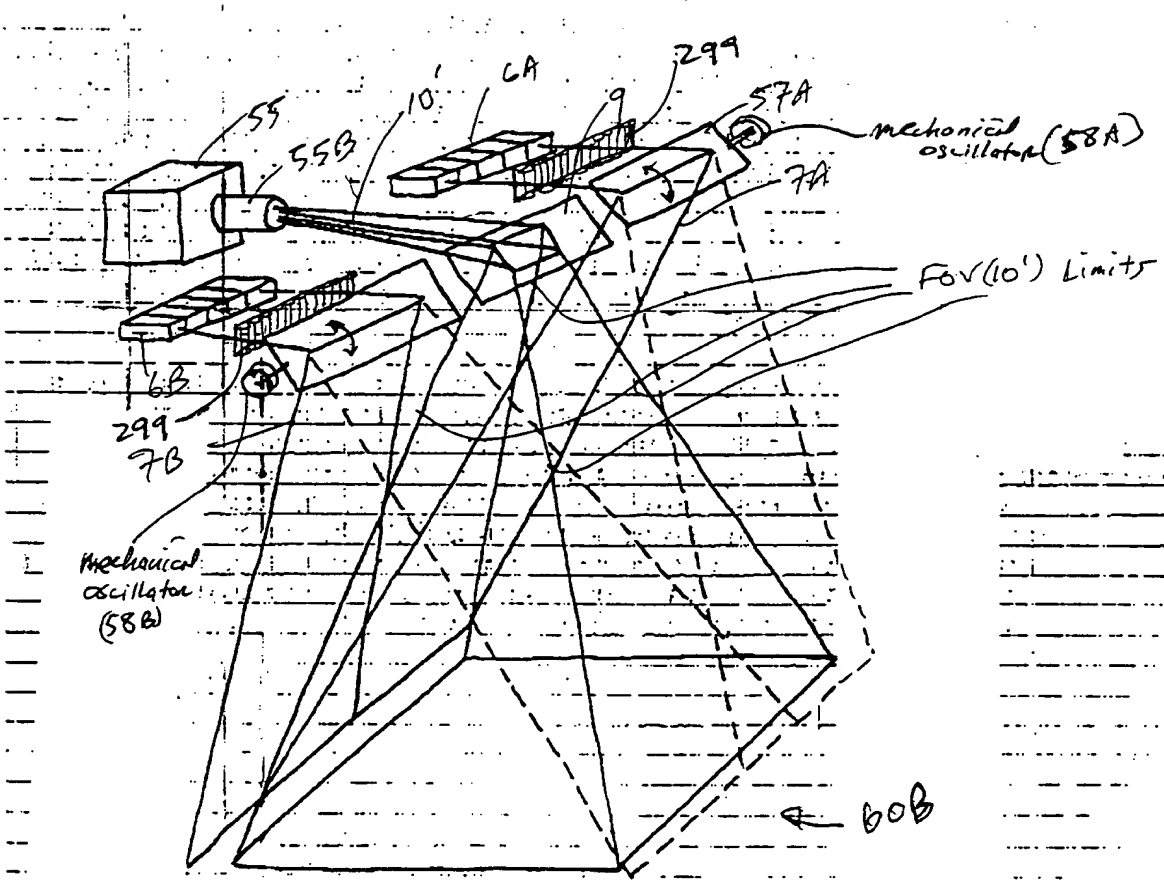

55
55B
10'
CA
9
299
57A
mechanical oscillator (58A)
7A
FoV(10') Limits
6B
299
7B
mechanical oscillator (58B)
60B

FIG 4C1

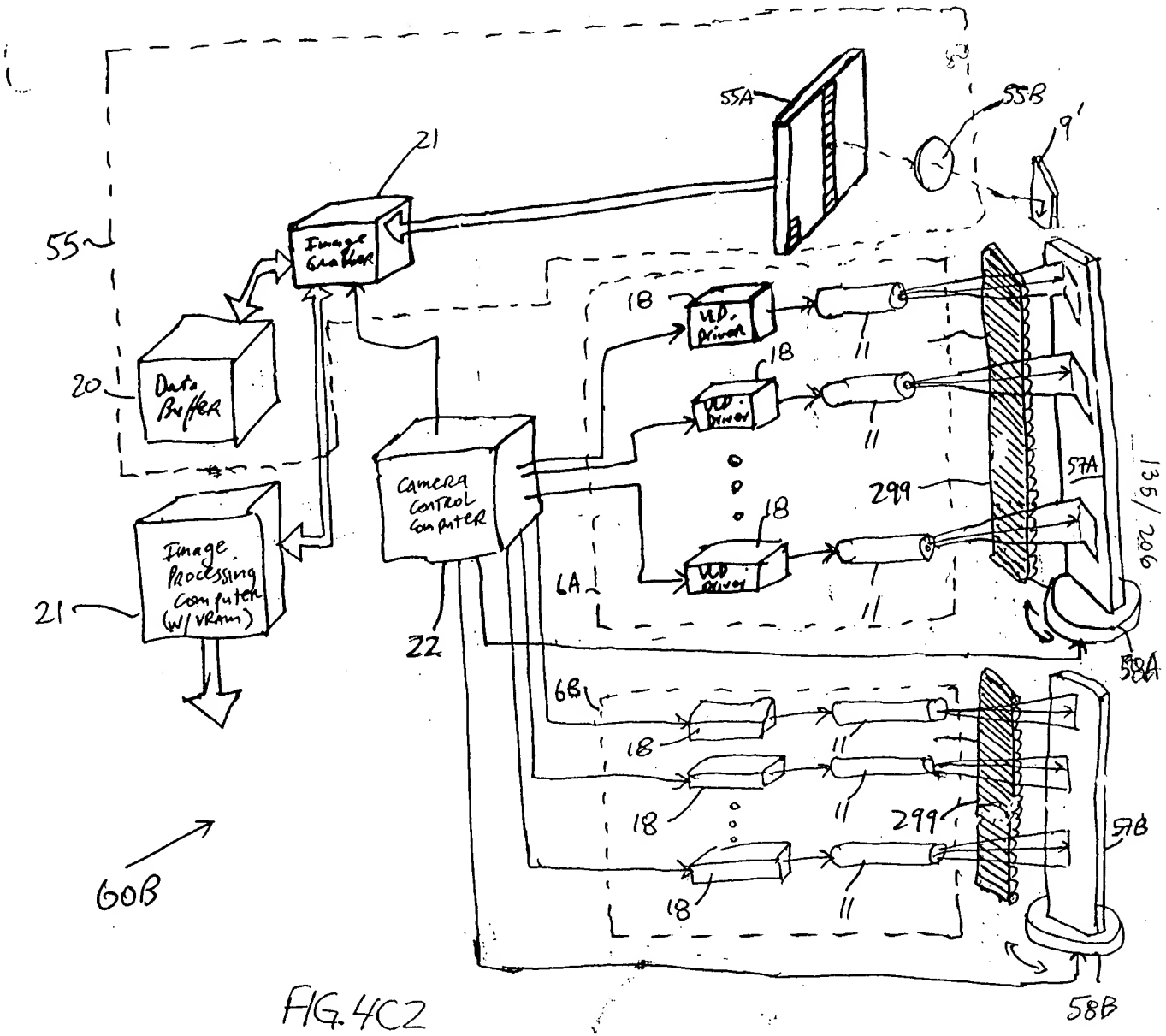


FIG. 4C2

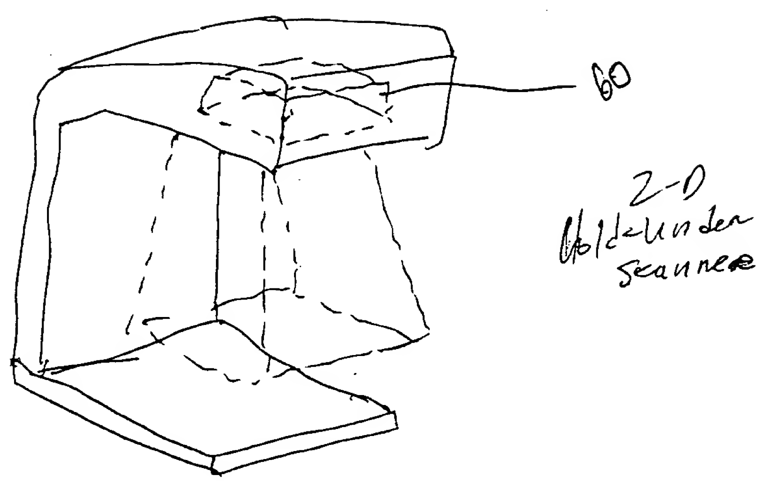
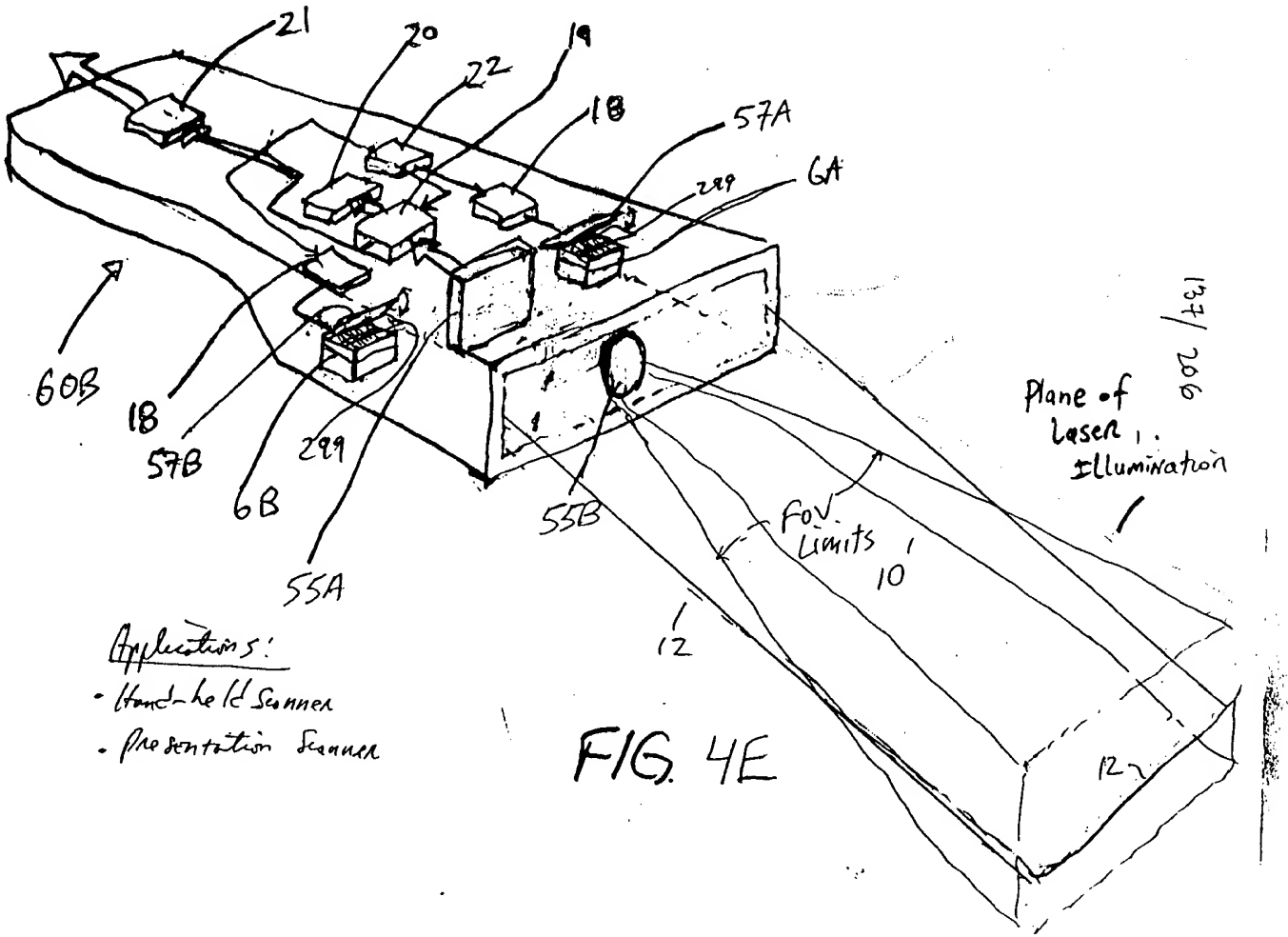
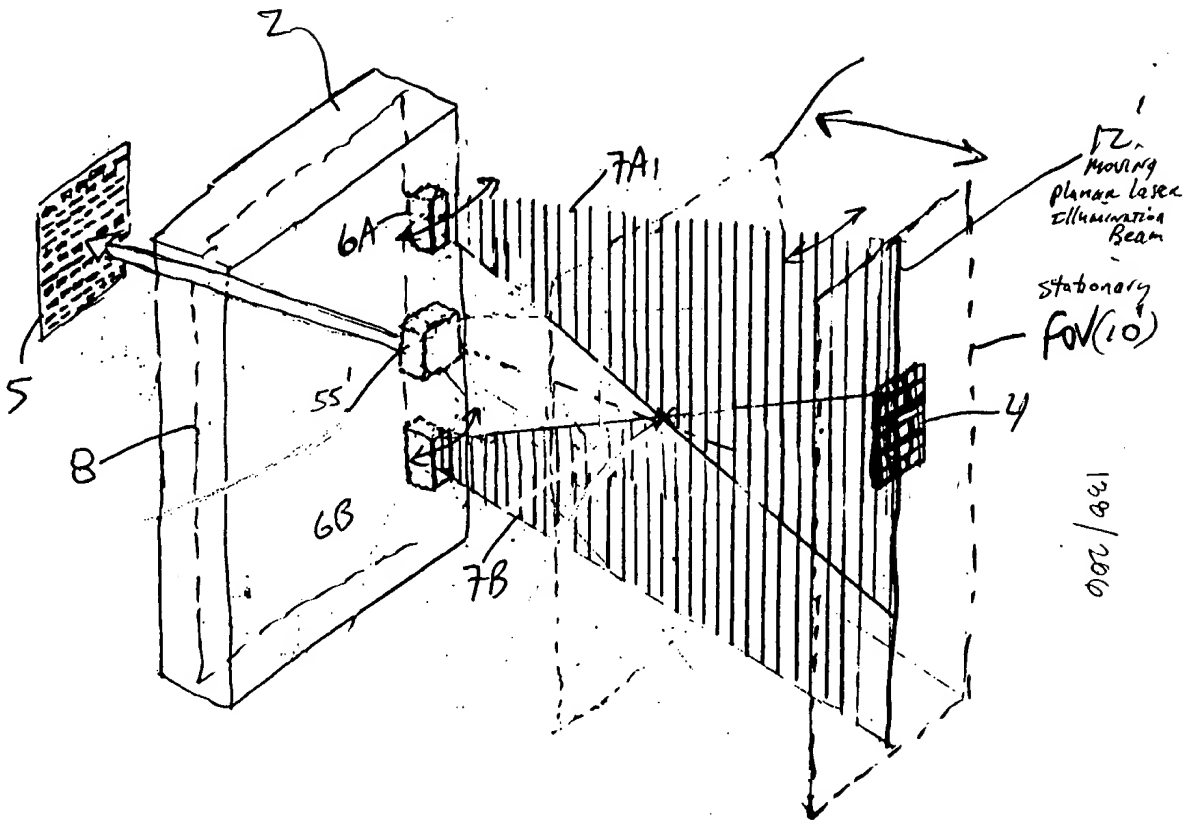


FIG. 4D



Applications:
- Hand-held Scanner
- Presentation Scanner

FIG. 4E



70

FIG 5A

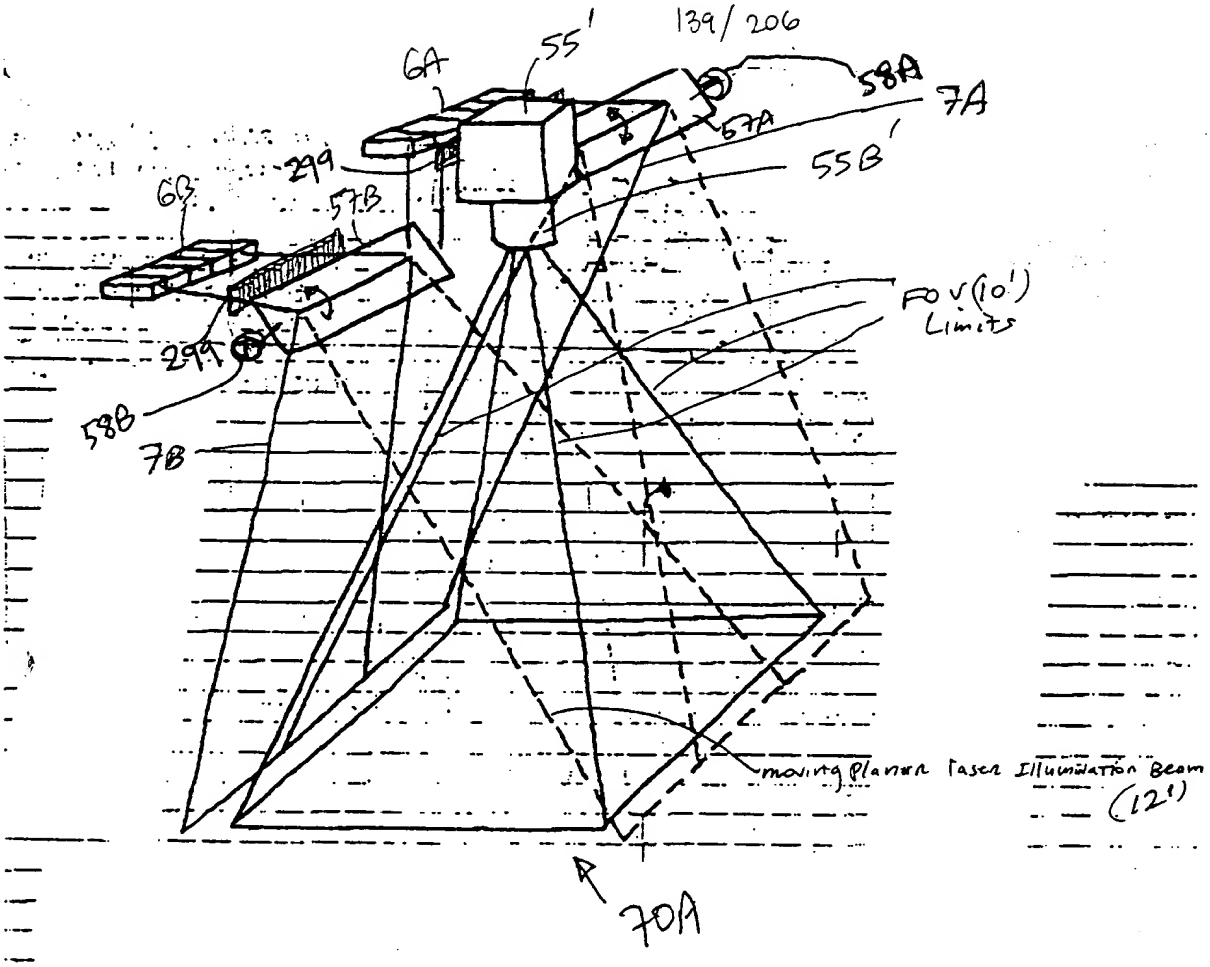

139/206
55'
6A
58A
7A
67A
55B'
299
57B
68
FOV (10')
Limits
299
58B
7B
moving Planar Laser Illumination Beam
(12')
70A

FIG 5B1

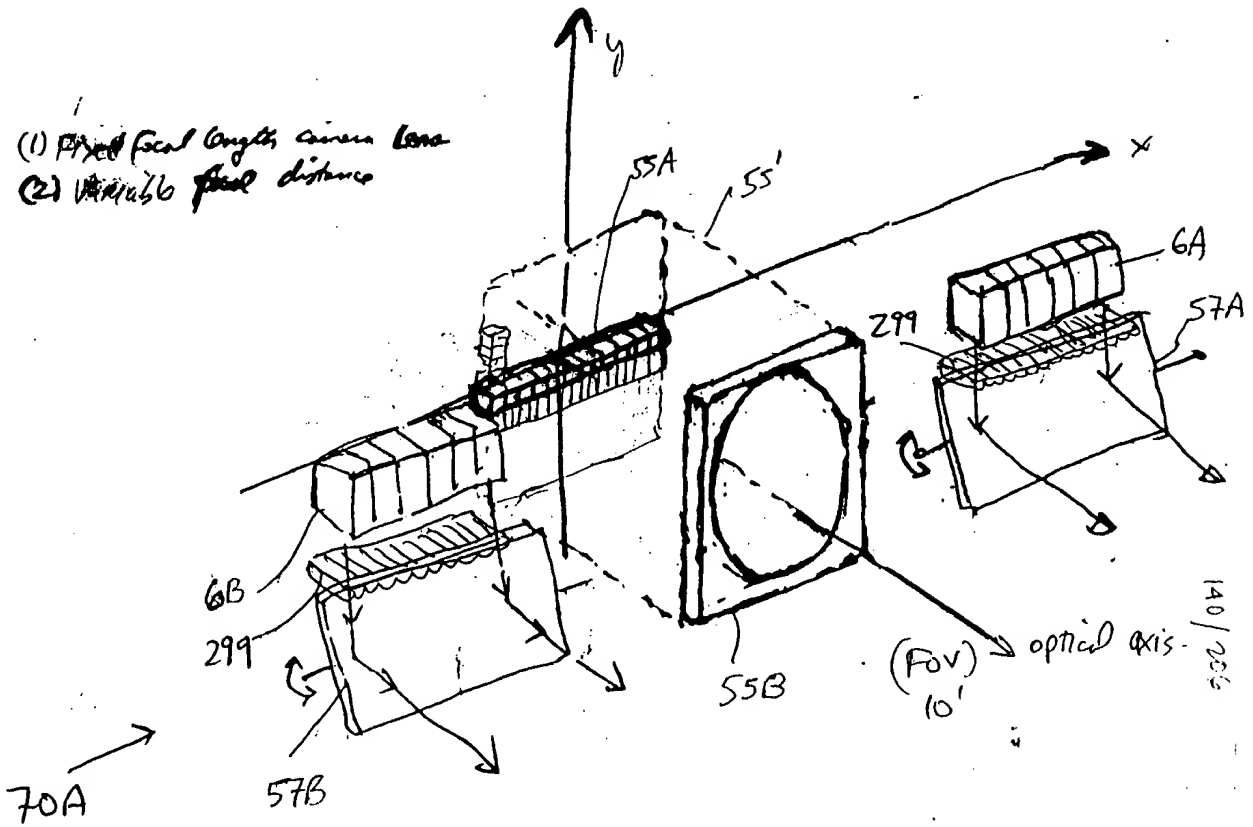
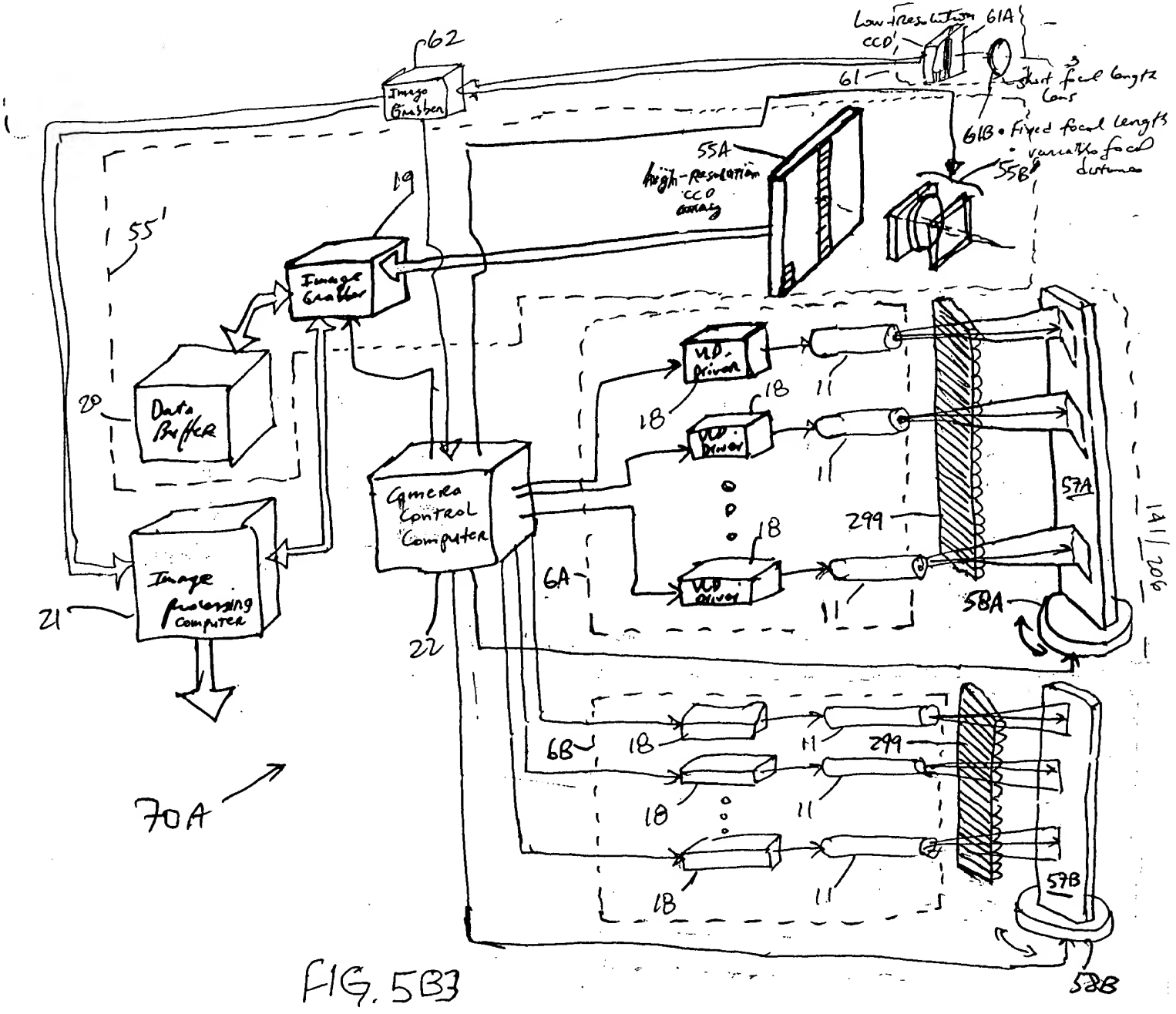


FIG. 5B2



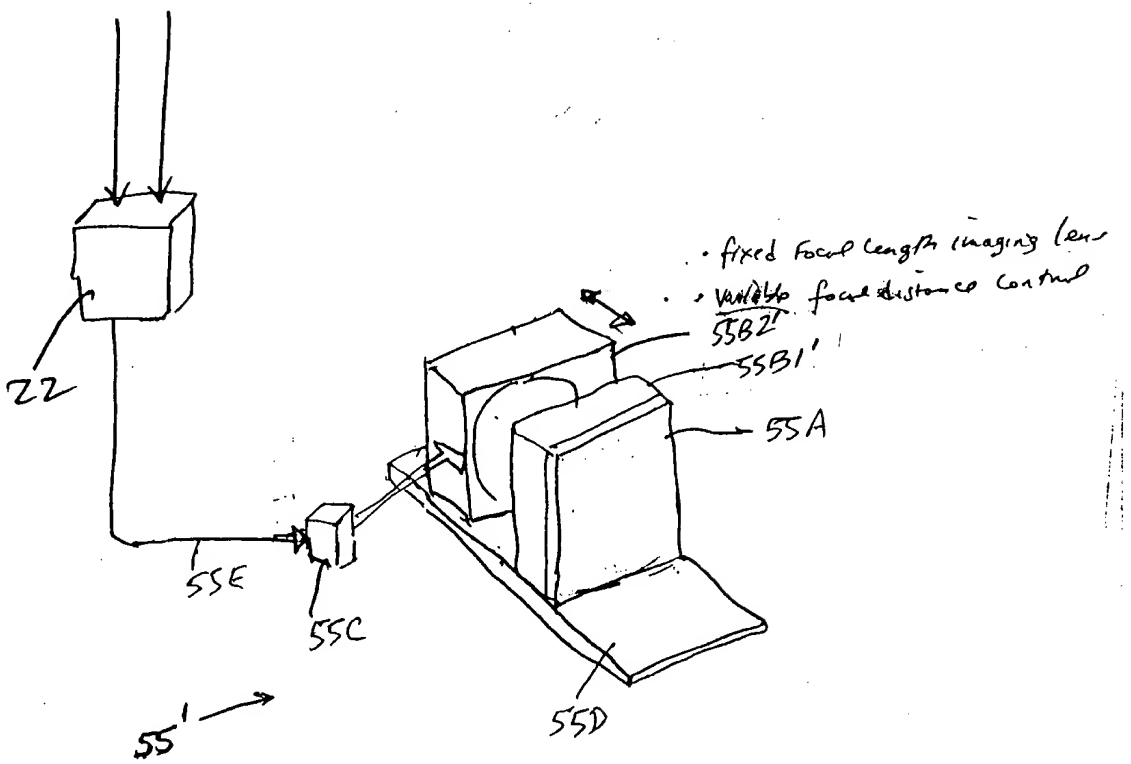

22
55E
55C
55'
55D
55A
55B1'
55B2'
· fixed focal length imaging lens
· variable focal distance control

FIG. 5B4

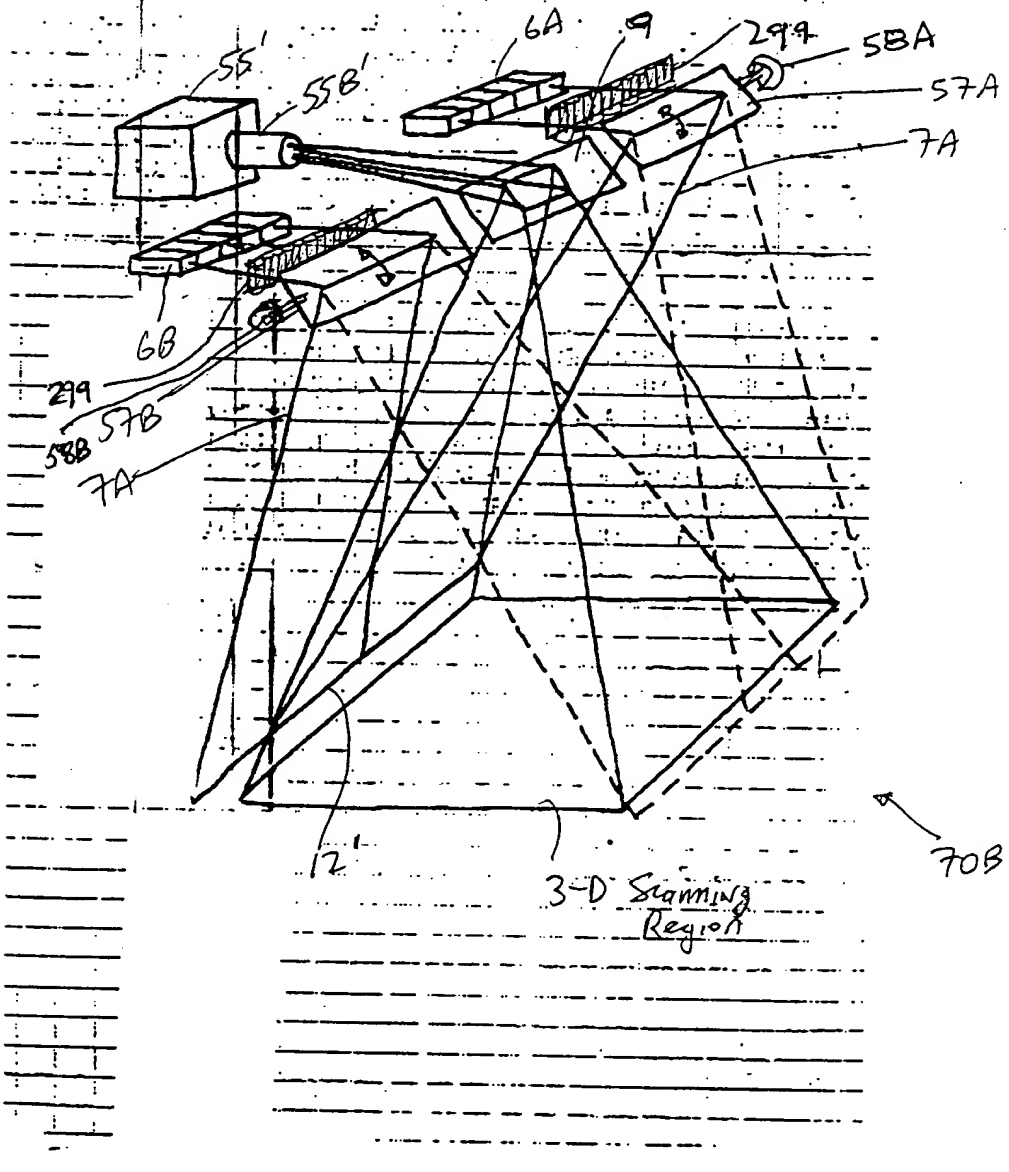

55'
55B'
6A
9
299
58A
57A
7A
6B
299
57B
58B
7A
12'
3-D Scanning Region
70B

FIG. 5C1

(1) variable focal length camera lens
(2) Fixed ~~focal~~ distance

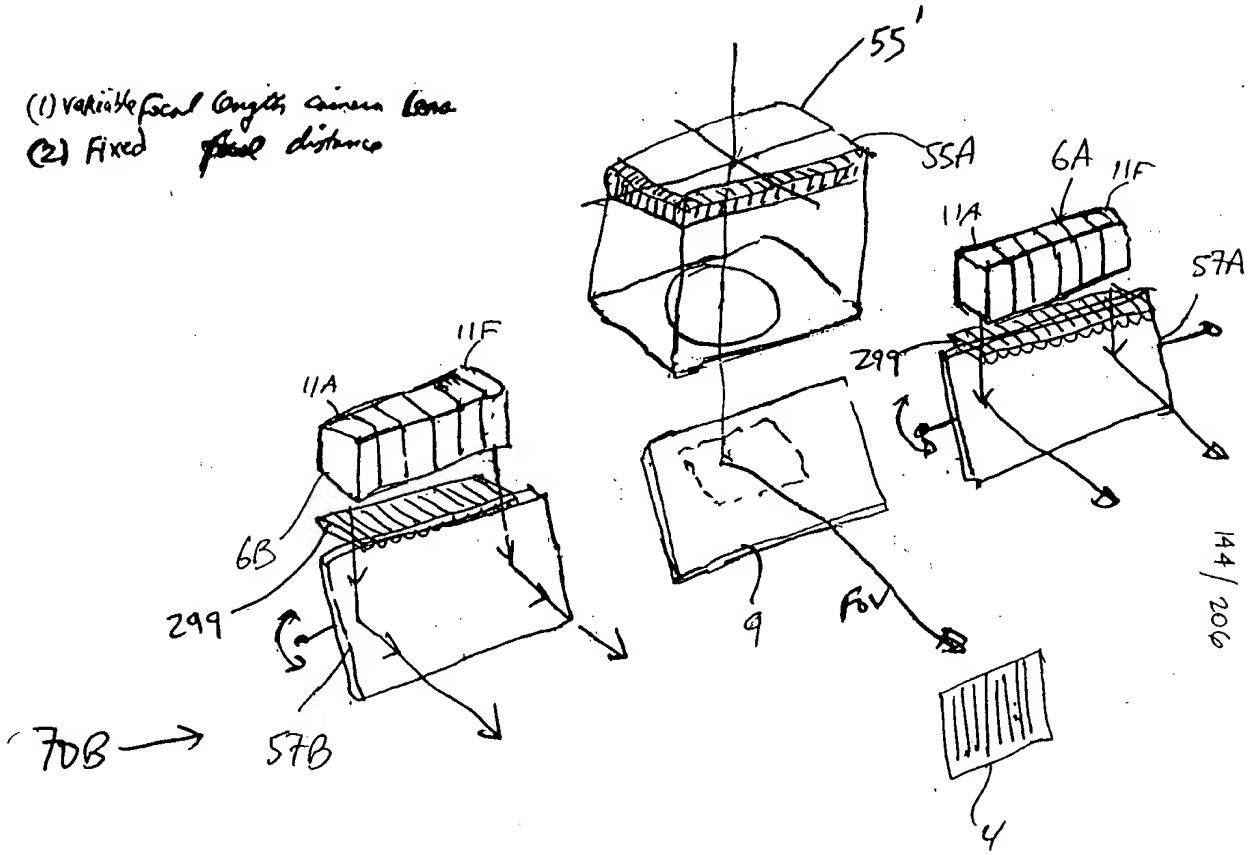


FIG. 5C

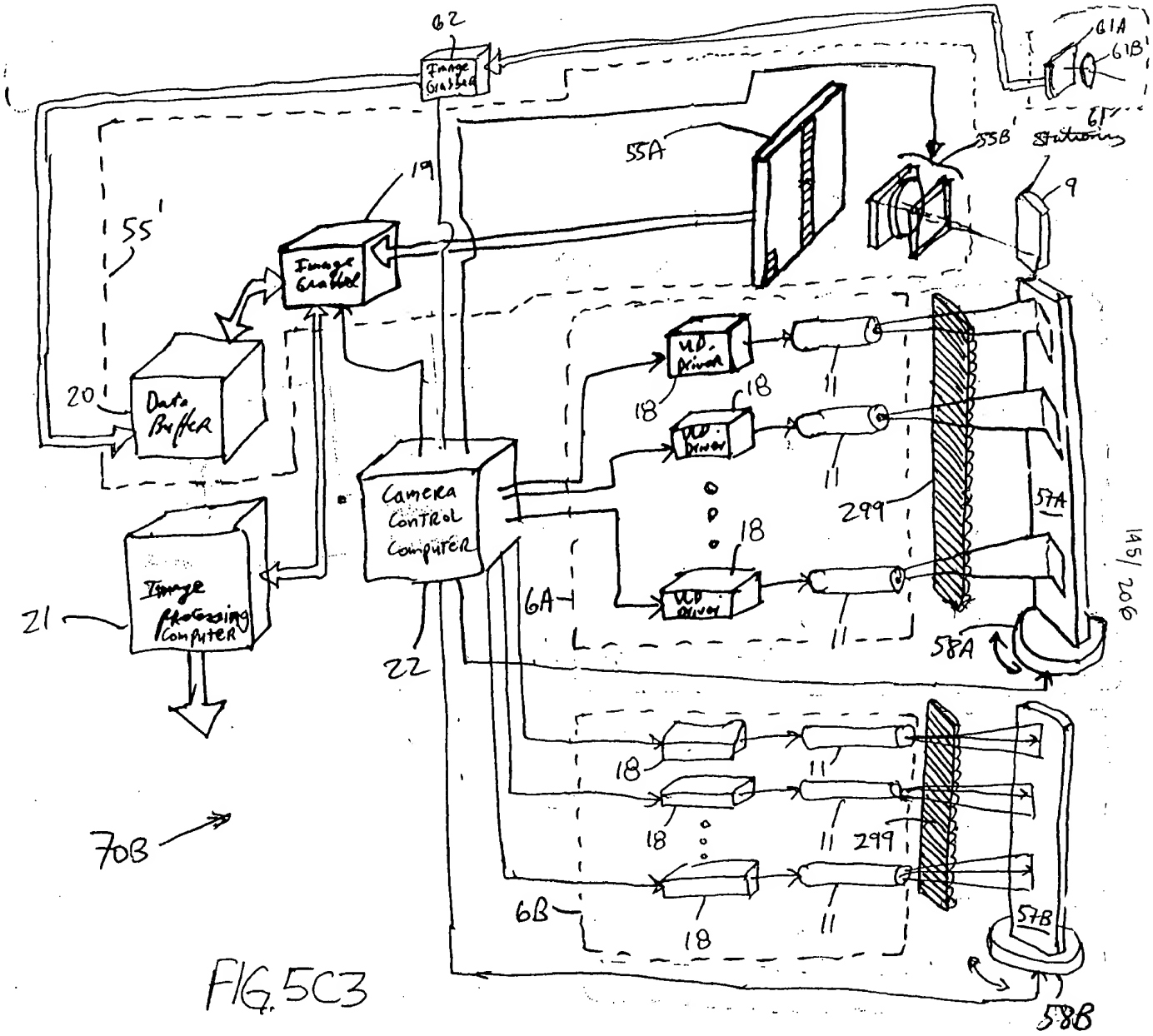

62
Image Grabber
61A
61B
61
55A
55B
55'
19
9
Image Grabber
20
Data Buffer
21
Image Processing Computer
Camera Control Computer
22
VCD Driver
18
11
299
57A
58A
6A
6B
57B
58B
70B

FIG. 5C3

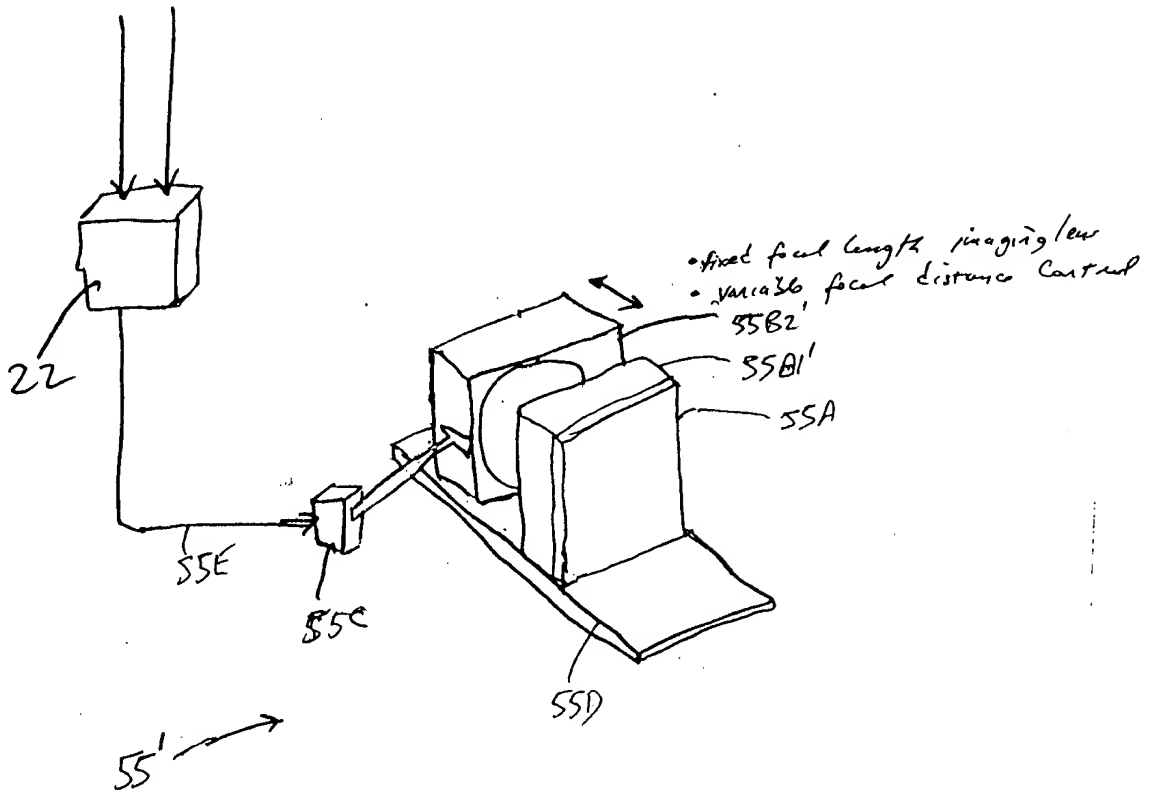

• fixed focal length imaging lens
• variable focal distance control
55B2'
55B1'
55A
22
55E
55C
55D
55'

FIG. 5C4

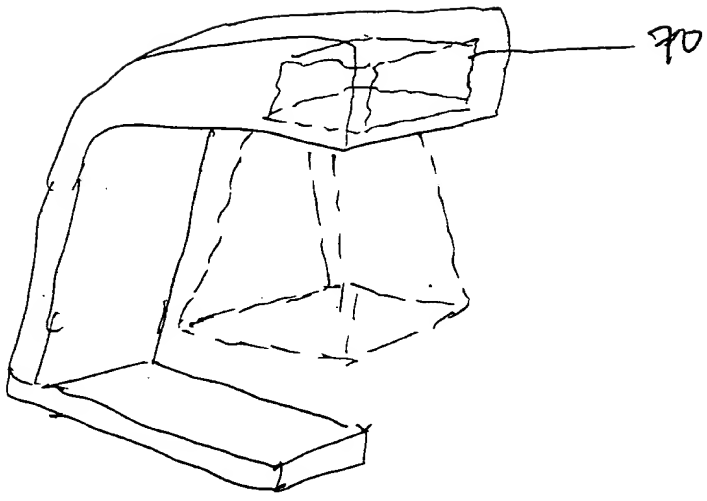
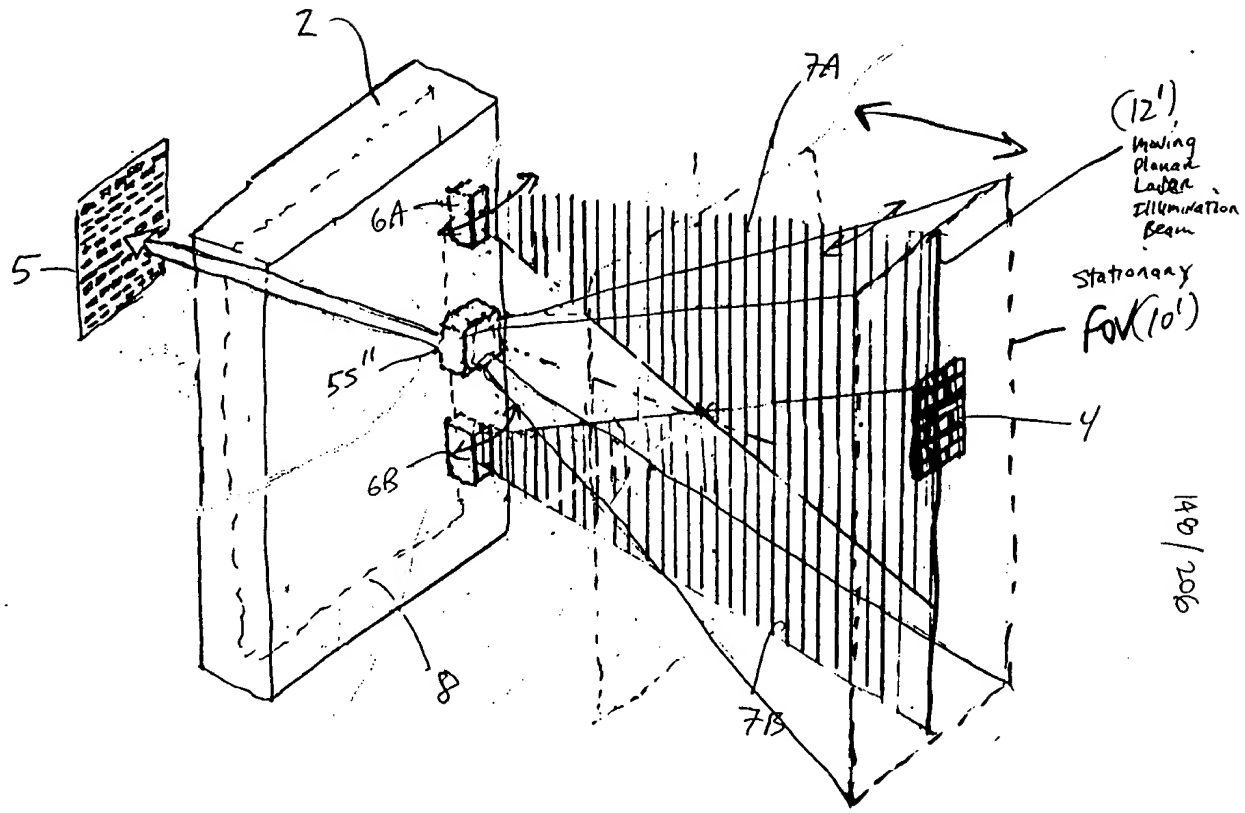


FIG. 5D



80

FIG. 6A

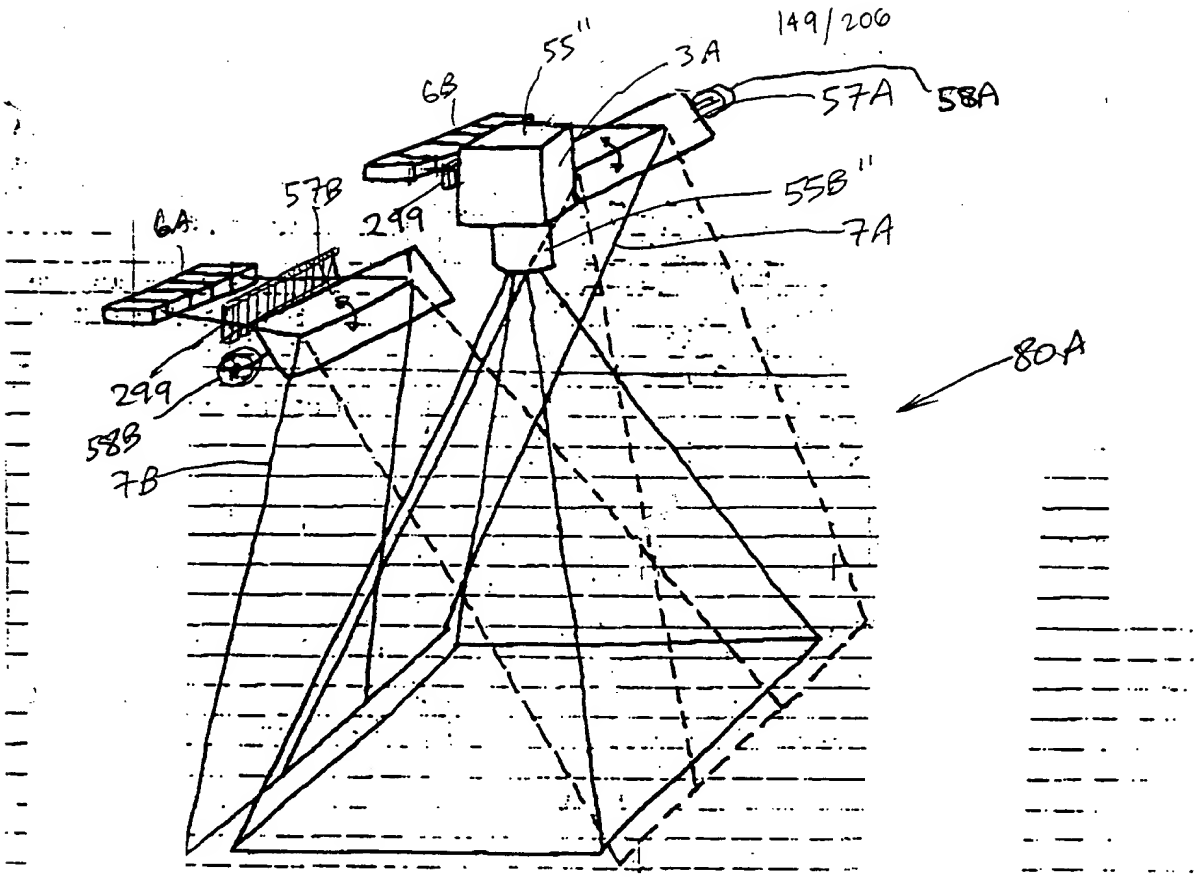


FIG. 6B1

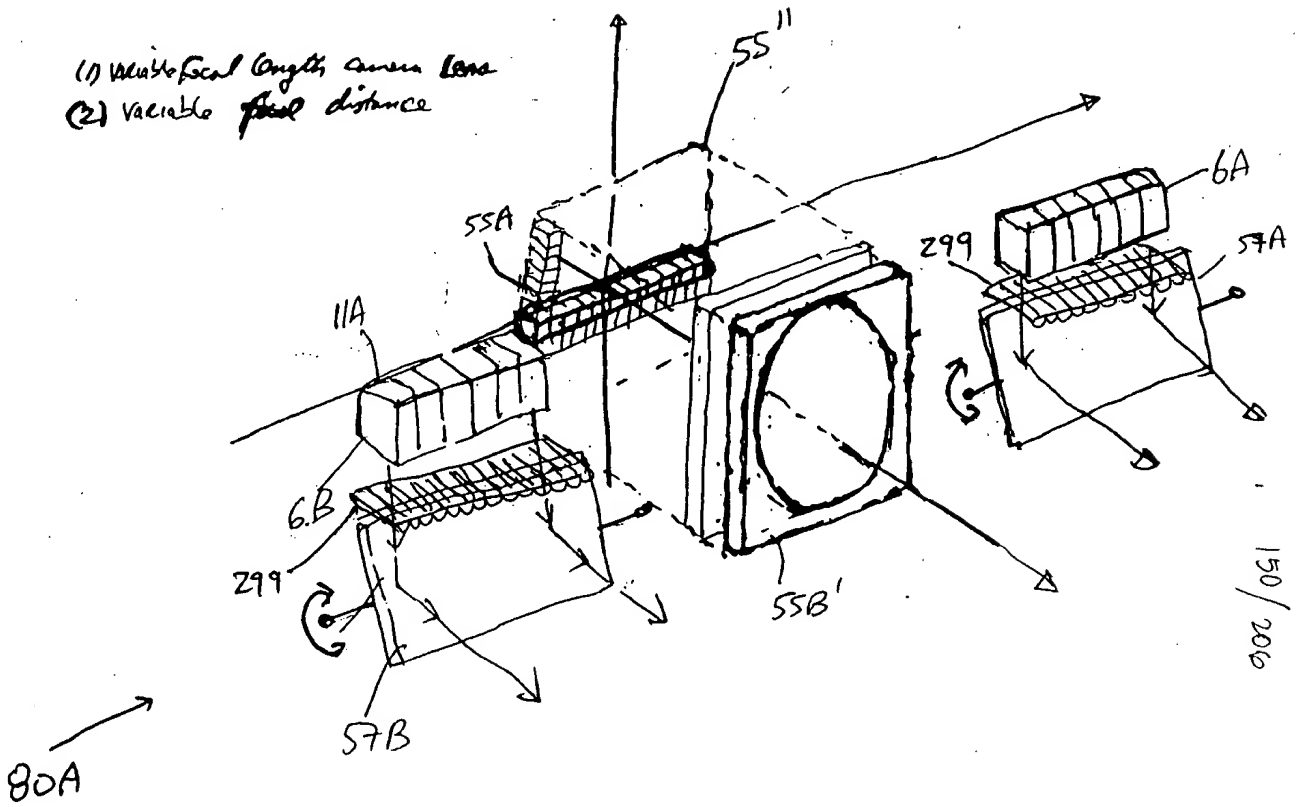


FIG. 6B2

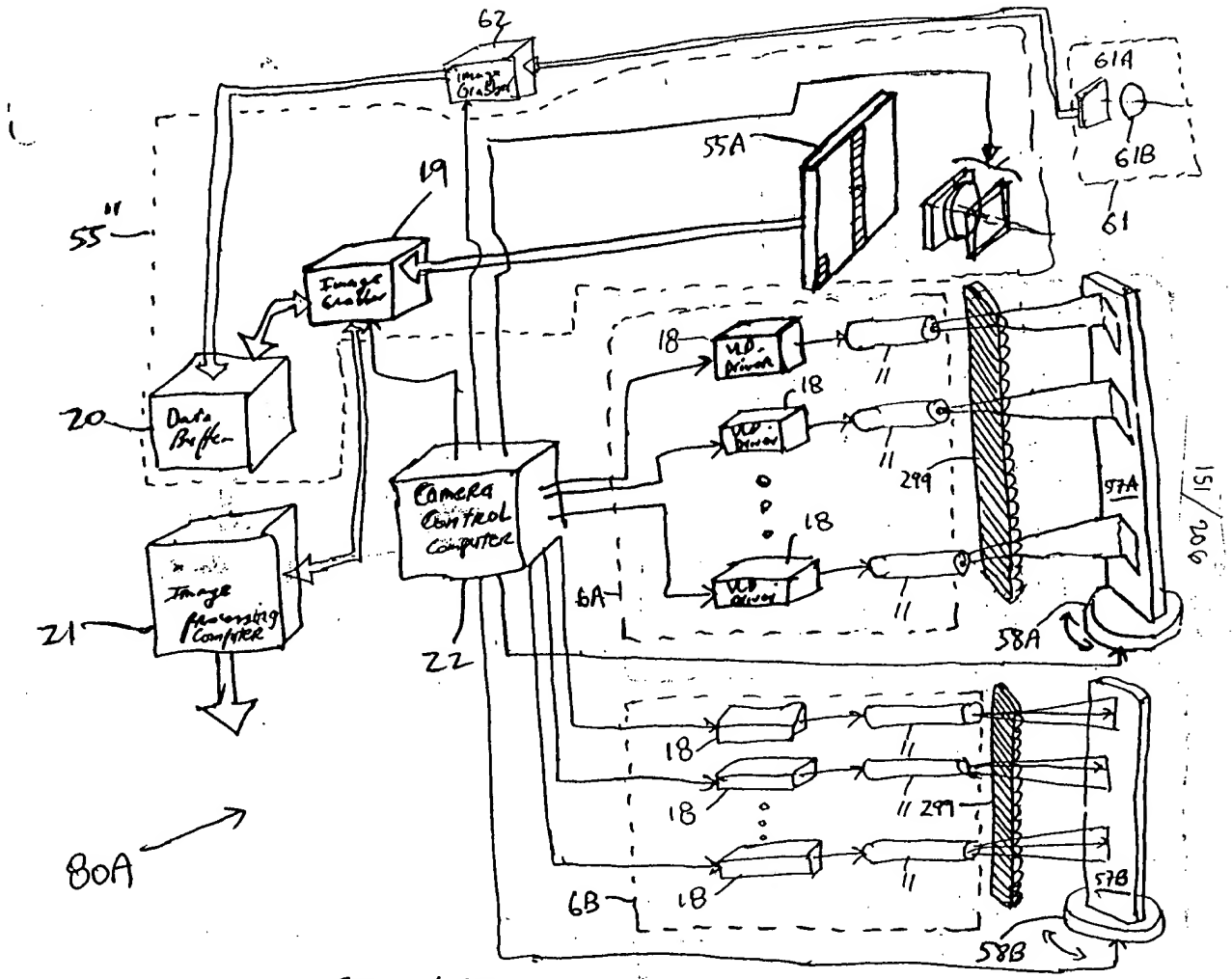


FIG. 6B3

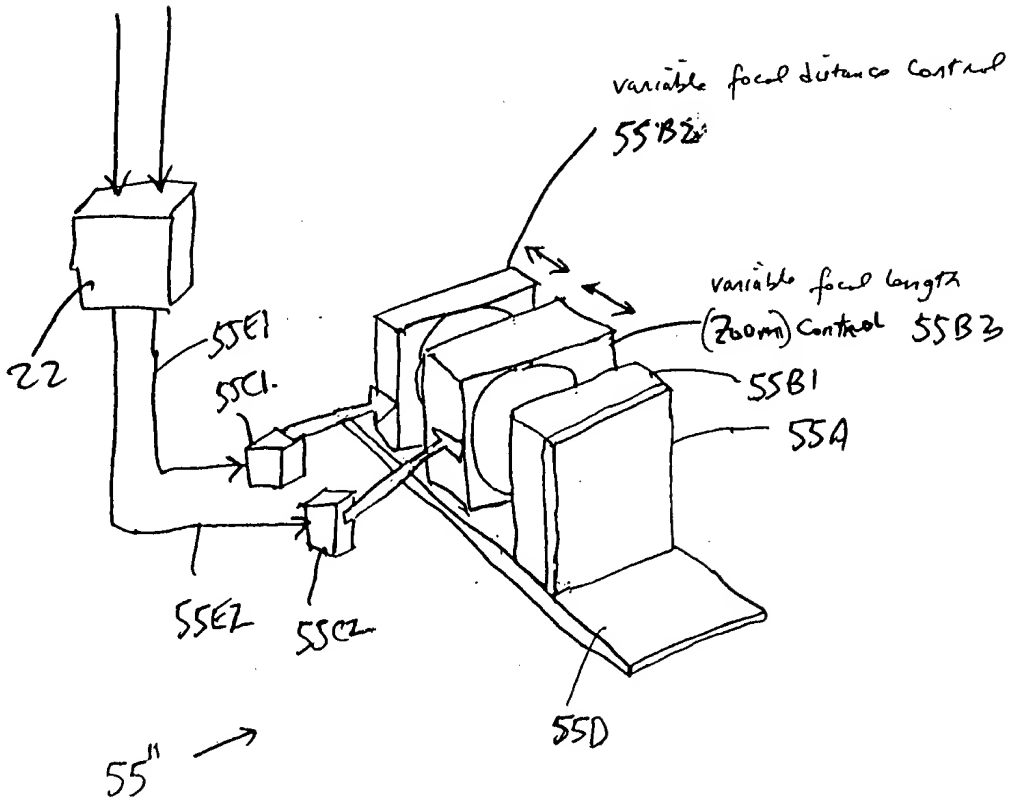


FIG. 6B4

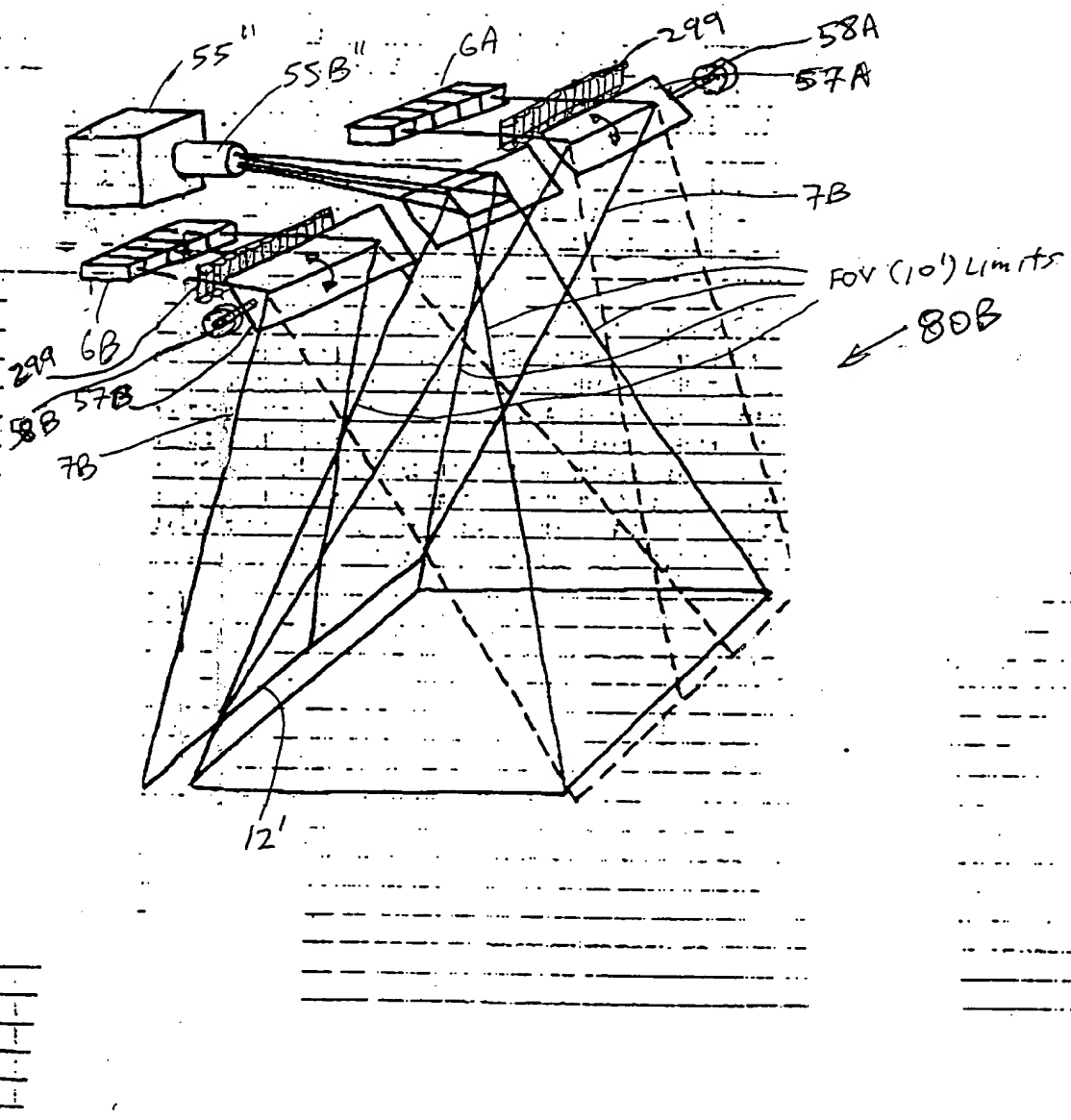


FIG. 6C1

(1) Variable focal length camera lens
(2) variable focal distance

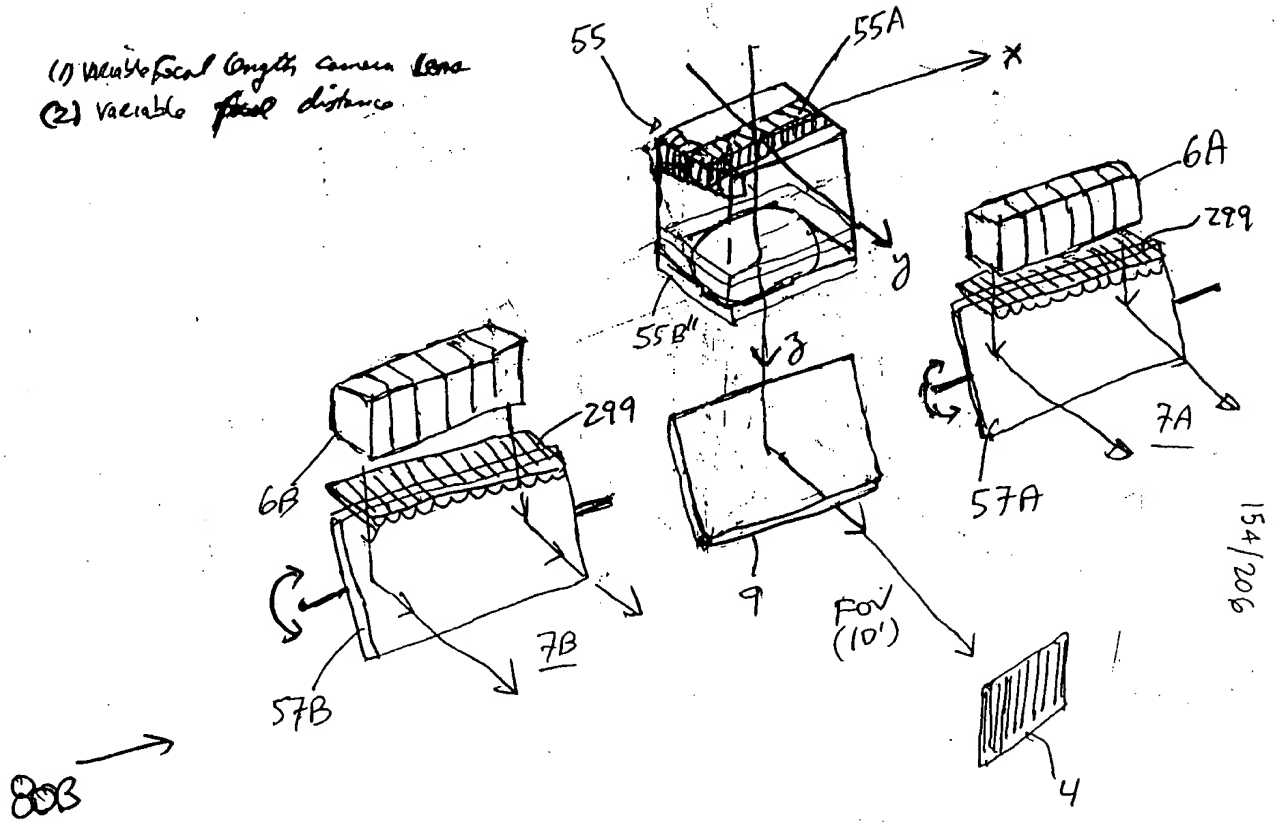


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FIG. 6C2

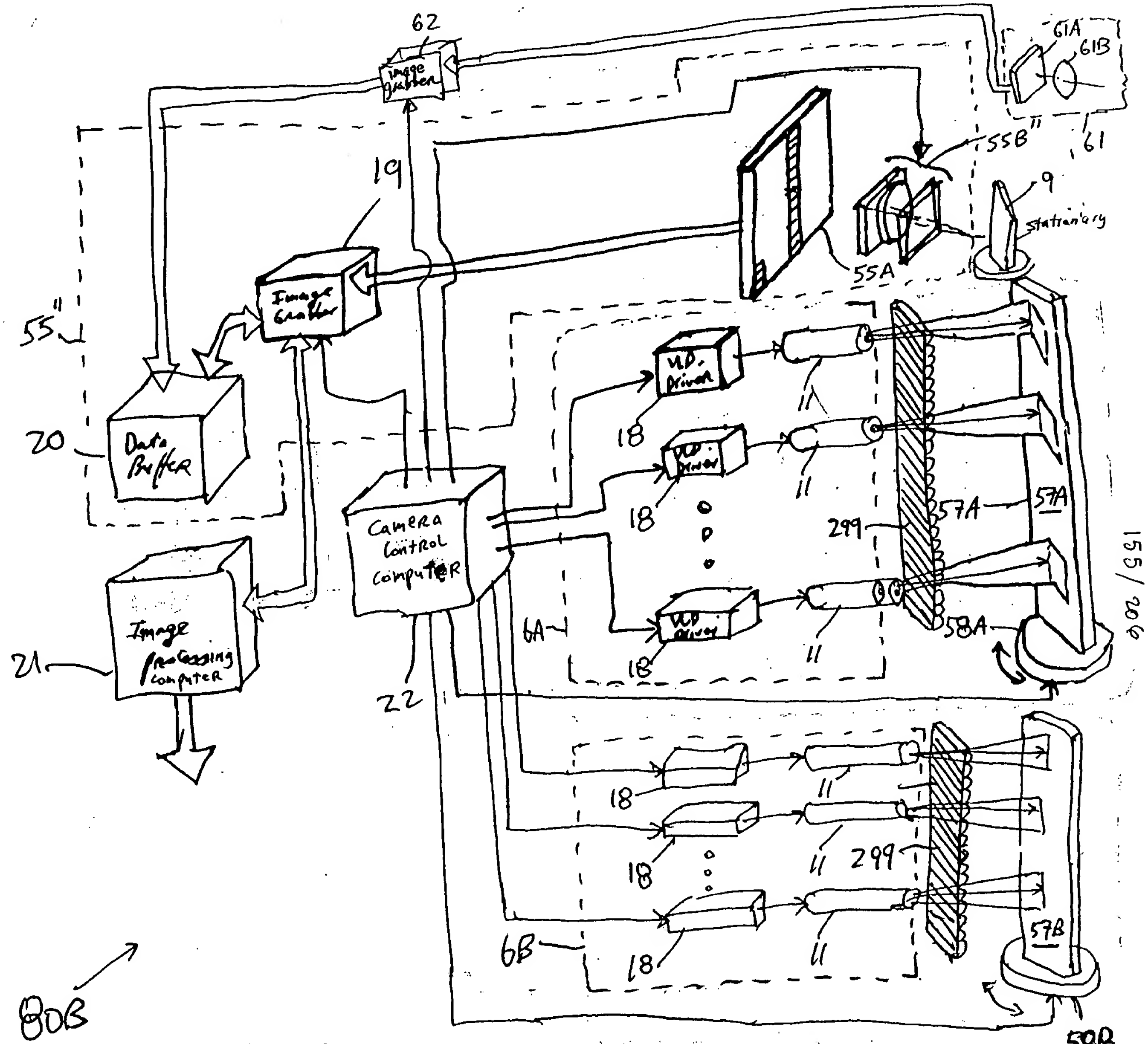
62
Image grabber
61A
61B
61
55B"
9
stationary
19
Image Grabber
55A
55"
20
Data Buffer
V.D. Driver
18
11
Camera Control Computer
57A
299
155/206
58A
6A
21
Image Processing Computer
22
18
11
299
6B
57B
58B
80B

FIG. 6C3

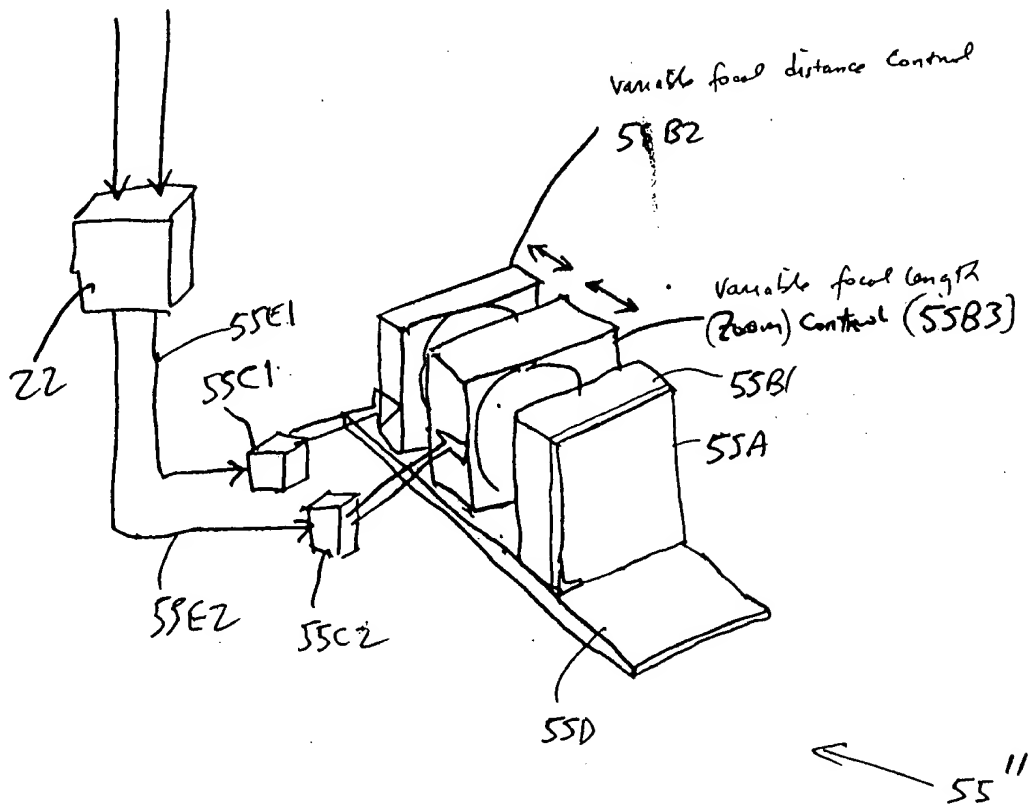

FIG. 6C4

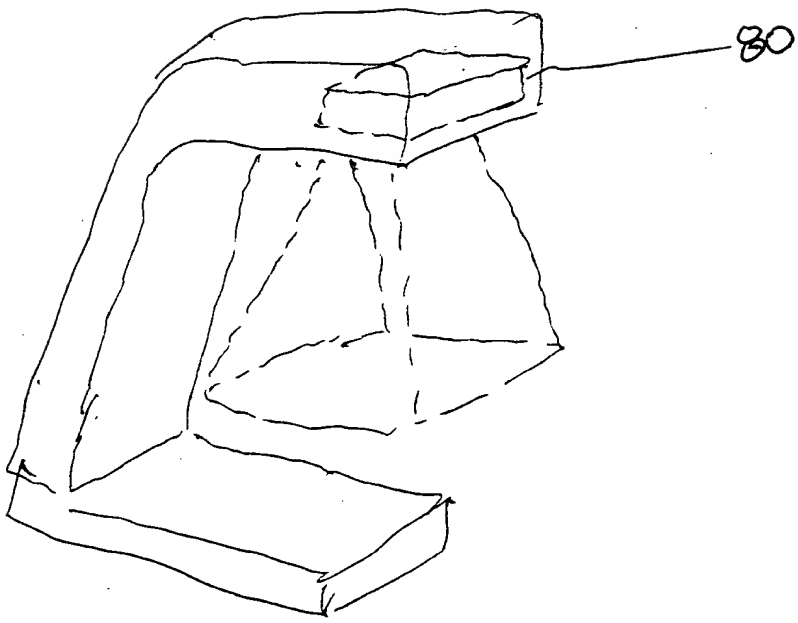

FIG. 6C5

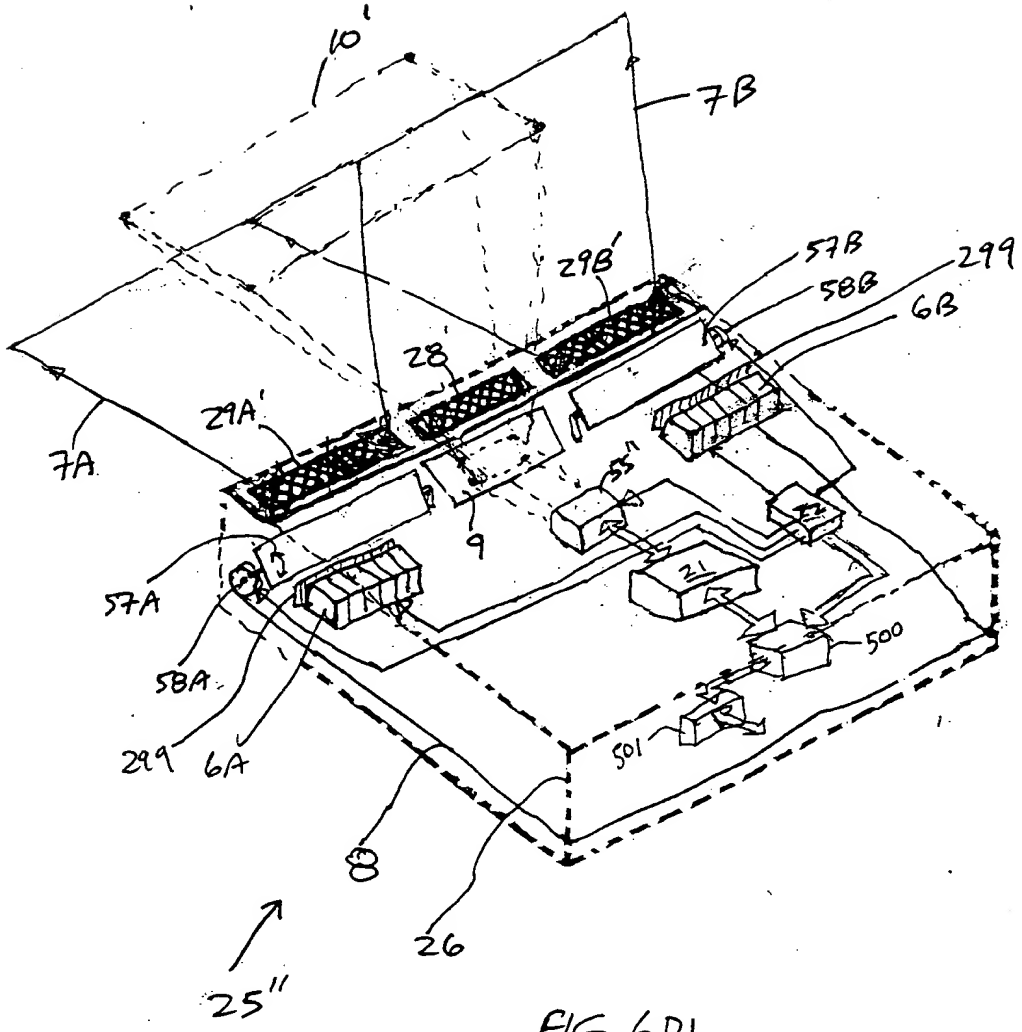
10'
7B
29B'
57B
58B
6B
299
28
29A'
7A
55'
9
57A
58A
299
6A
21
500
501
8
26
25"

FIG. 6D1

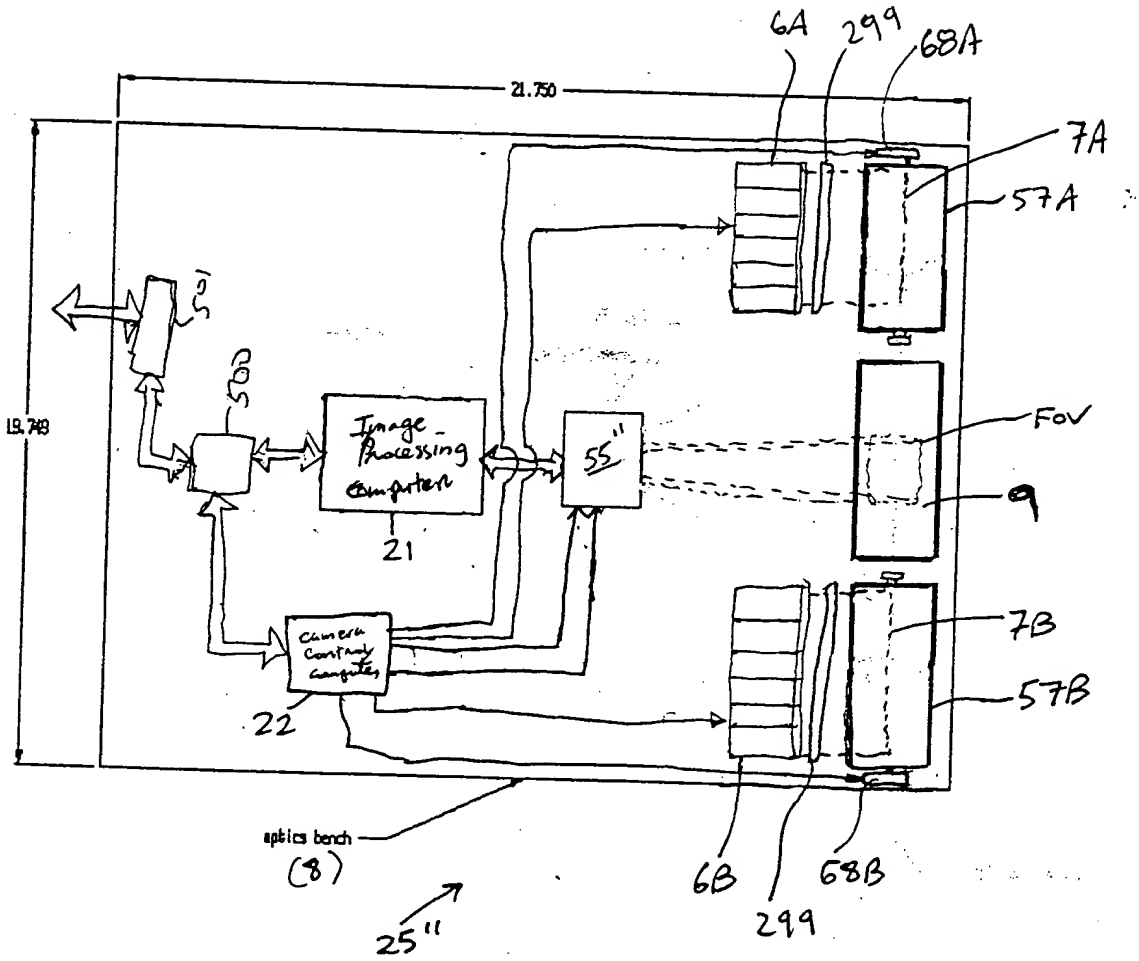
6A
299
68A
21.750
7A
57A
19.749
FoV
9
Image Processing computer
21
55"
camera Control computer
22
7B
57B
optics bench
(8)
6B
68B
299
25"

FIG. 6D2

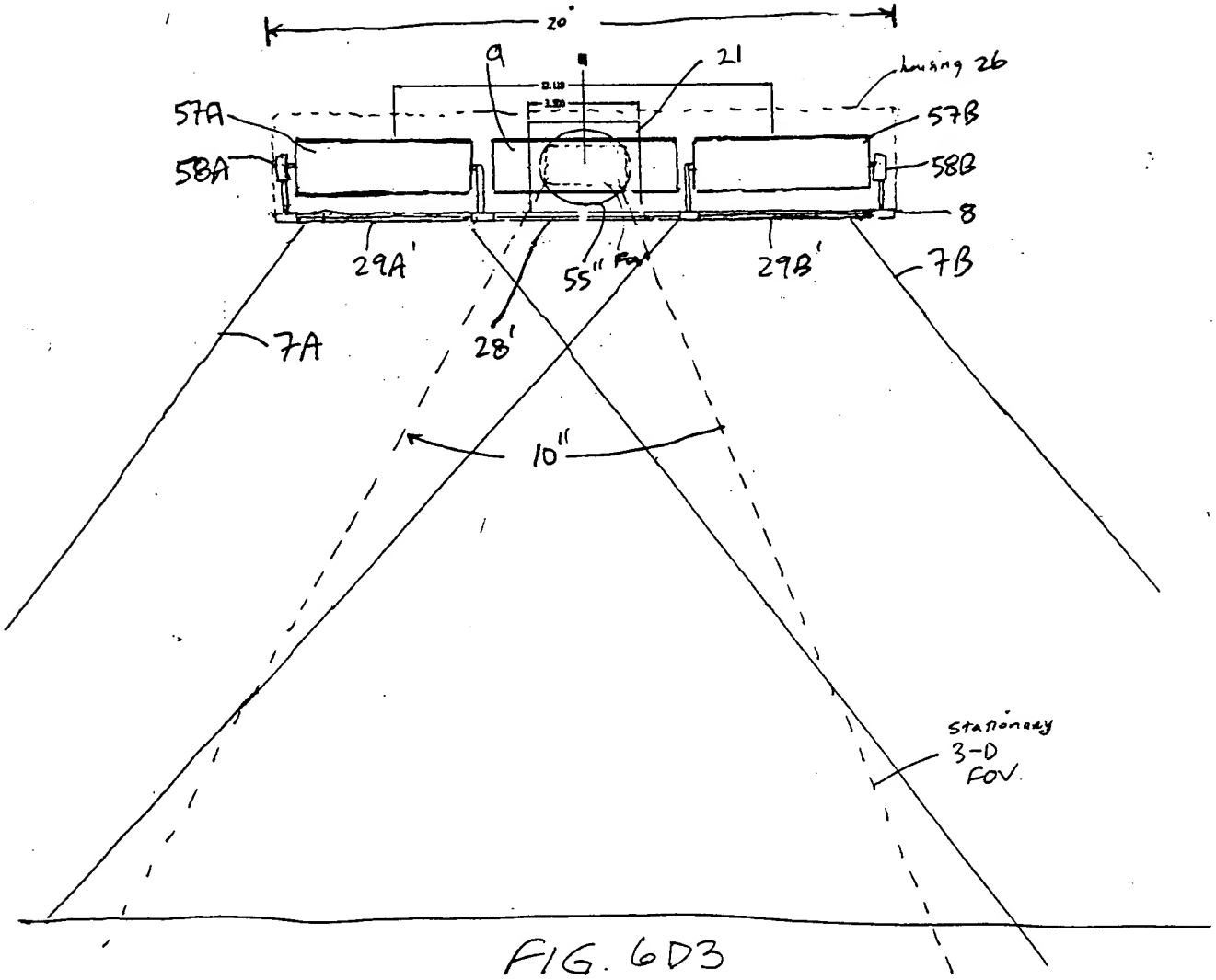
20°
9
21
housing 26
57A
57B
58A
58B
8
29A'
55° FOV
29B'
7B
7A
28'
10"
stationary
3-D
FOV

FIG. 6D3

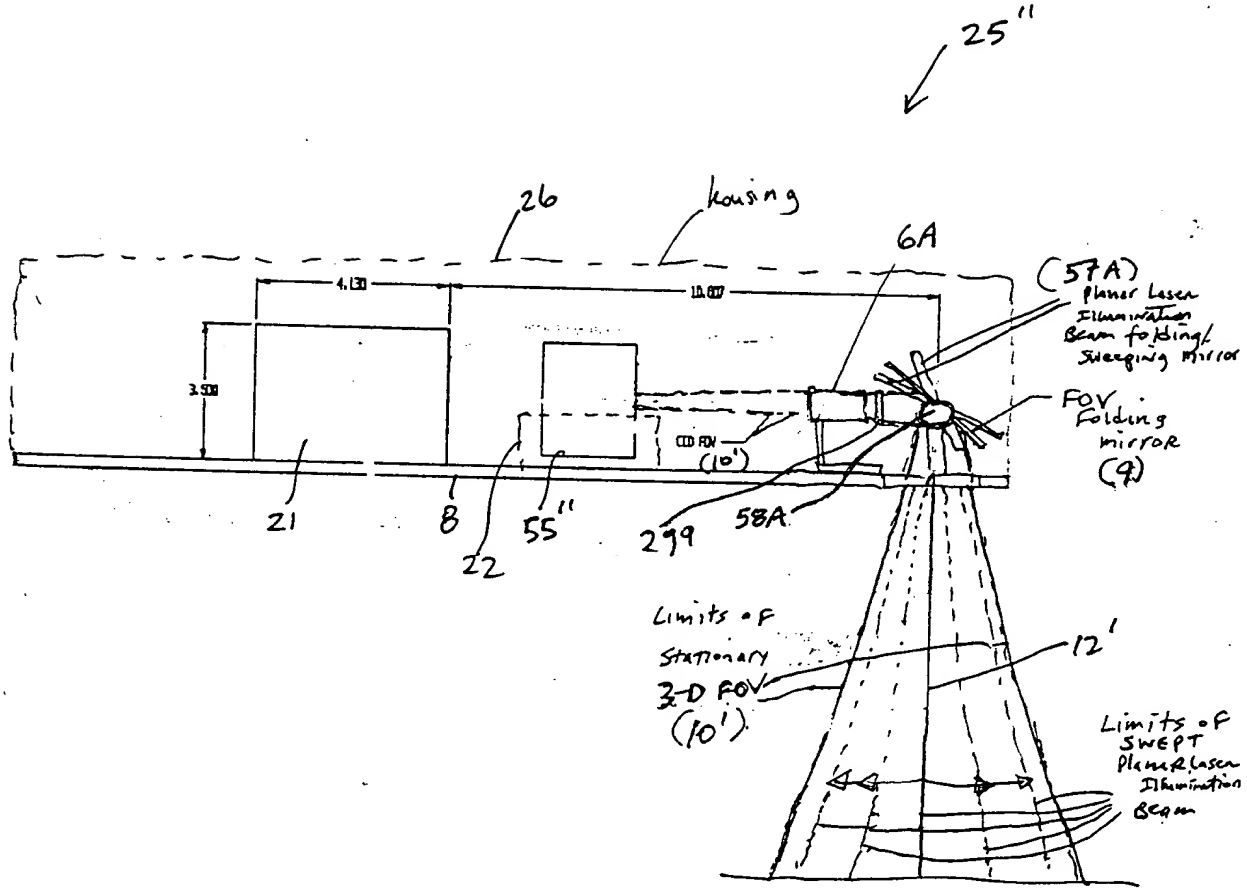
25''
26
housing
6A
(57A)
Planar Laser Illumination Beam folding/ sweeping mirror
FOV Folding mirror (9)
4.13
10.677
3.500
CCD FOV (10')
21
8
22
55''
299
58A
Limits of Stationary 3-D FOV (10')
12'
Limits of SWEPT Planar Laser Illumination Beam

FIG. 6D4

variable FOV

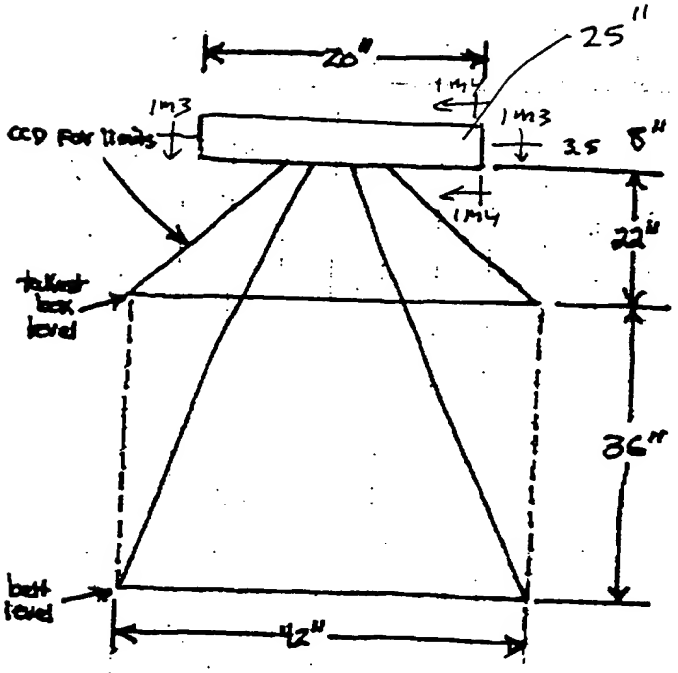

FIG. 6D5

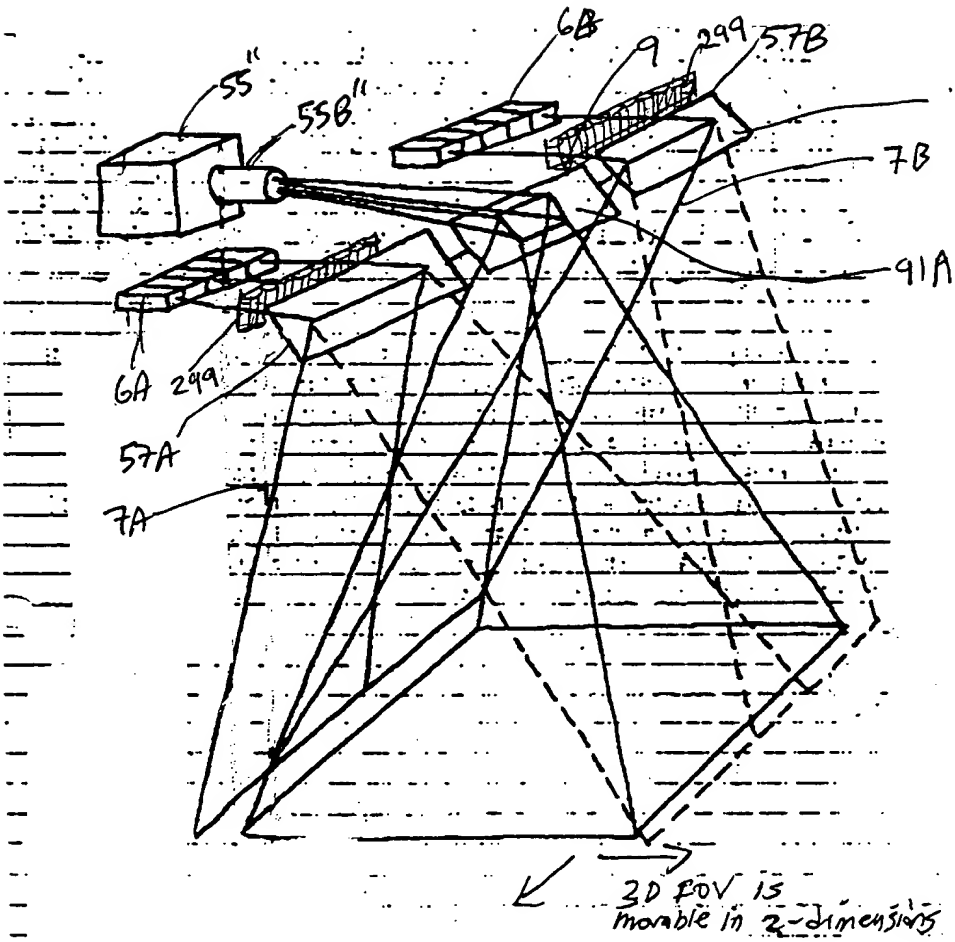
6B
9
299
57B
55"
55B"
7B
91A
90
6A
299
57A
7A
3D FOV is
movable in 2-dimensions

FIG 6E1

(1) Variable focal length camera lens
(2) variable focal distance

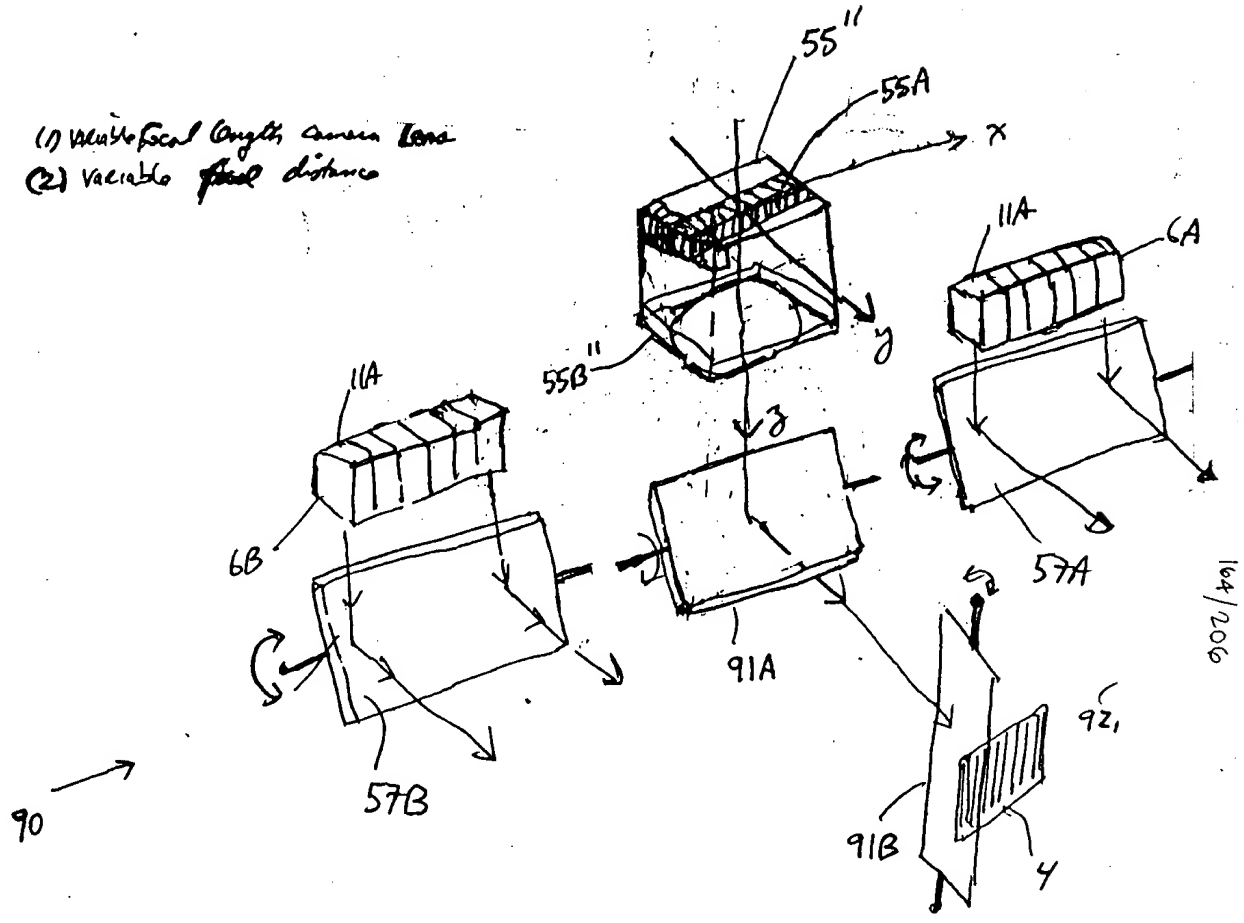

FIG. 6E2

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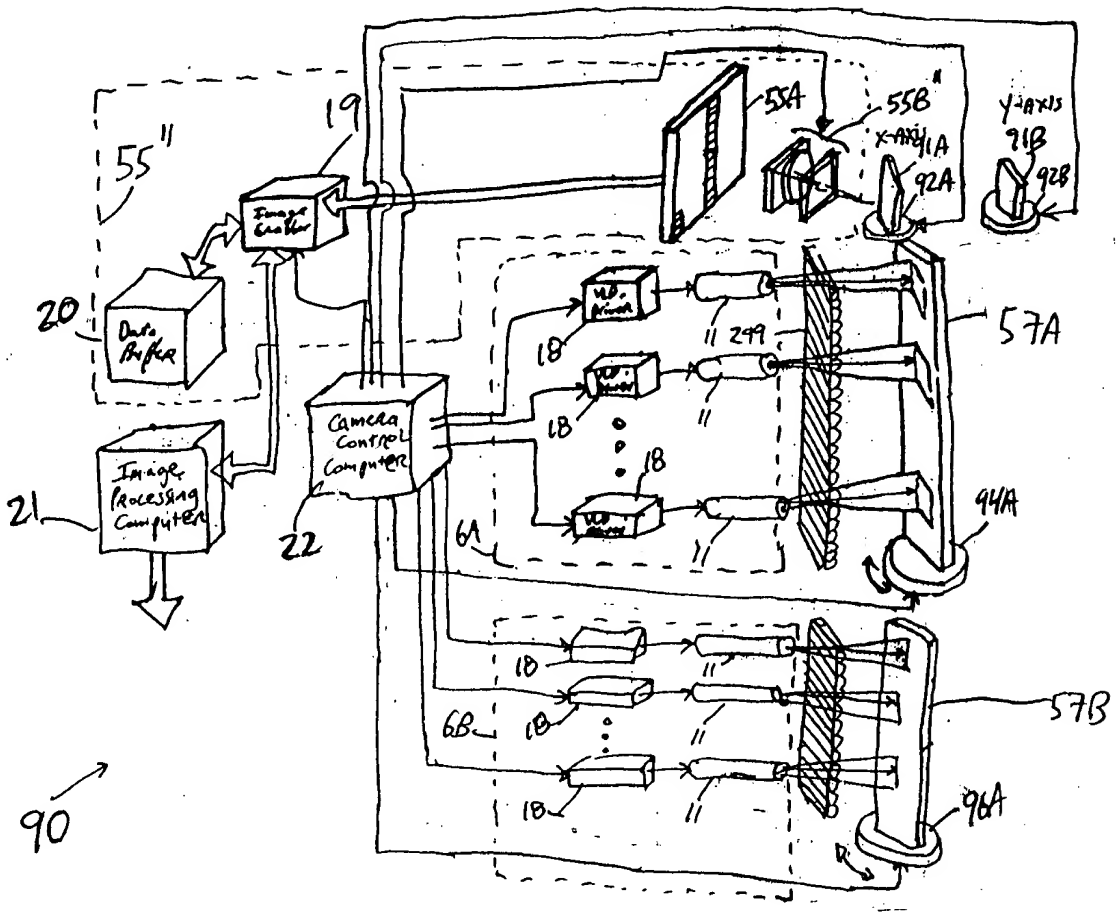

55"
19
55A
55B"
X-AXIS
91A
92A
Y-AXIS
91B
92B
20
Data Buffer
Image Processing Computer
21
22
Camera Control Computer
18
18
18
299
57A
94A
6A
18
18
18
6B
57B
96A
90

FIG. 6E3

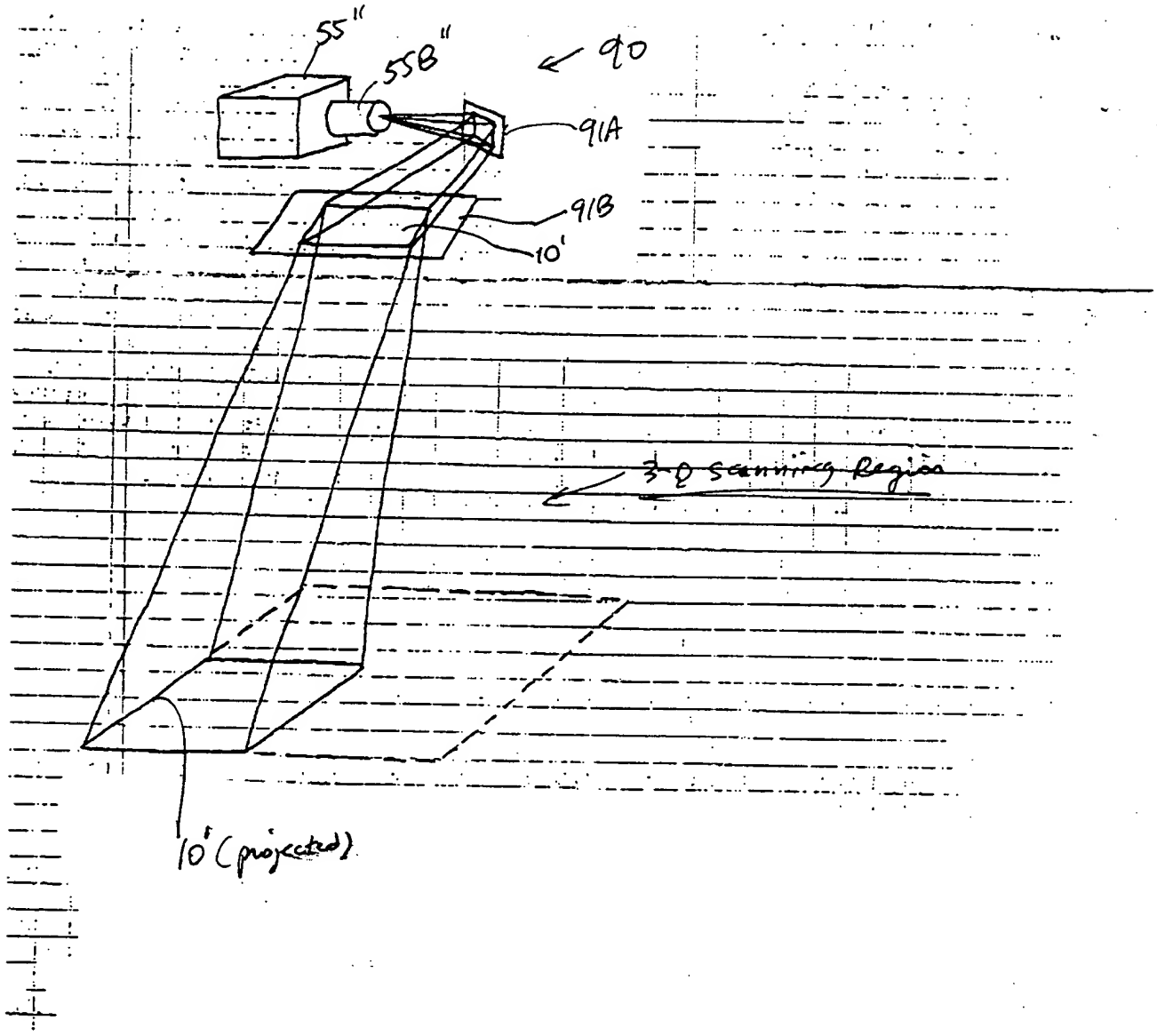


FIG 6E4

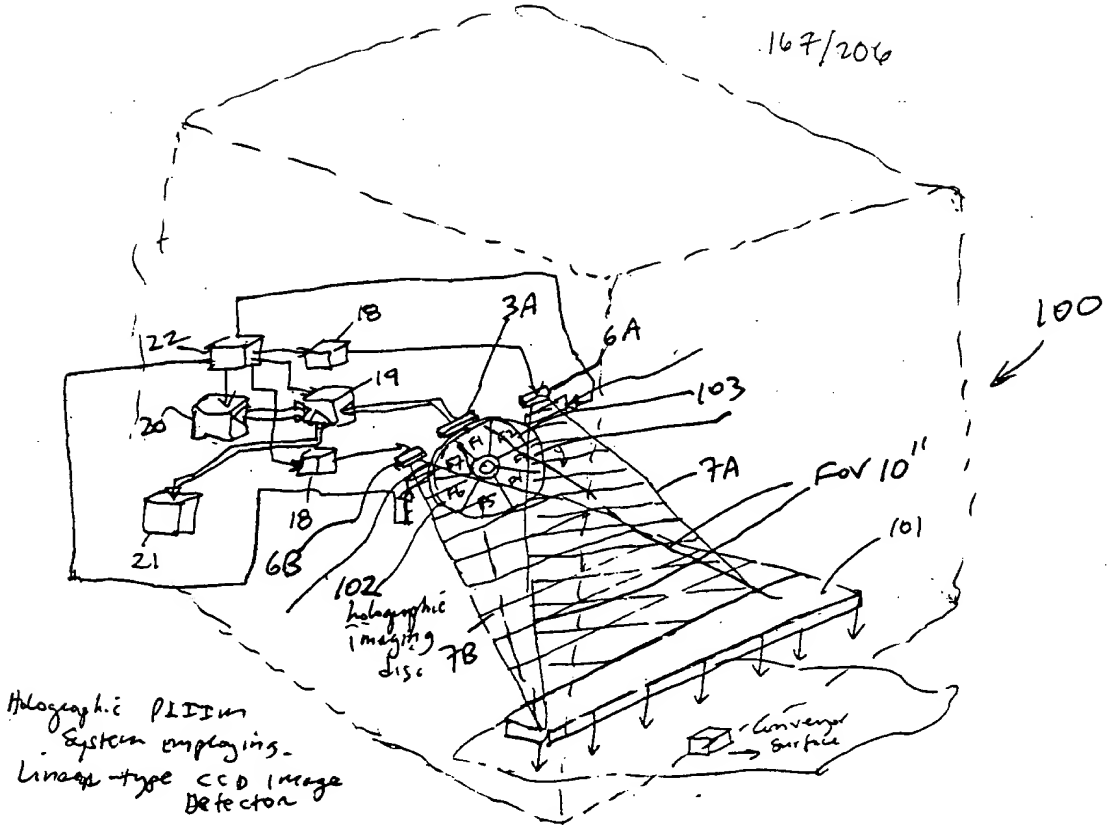

100
22
18
3A
6A
19
103
20
7A
FoV 10''
18
101
21
6B
102
holographic imaging disc
7B
Holographic PLIIM System employing Linear-type CCD Image Detector
Conveyor Surface

FIG. 7A

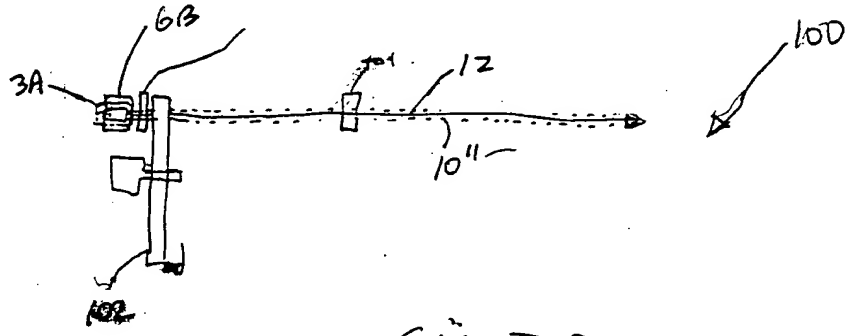

6B
3A
12
100
10''
102

FIG. 7B

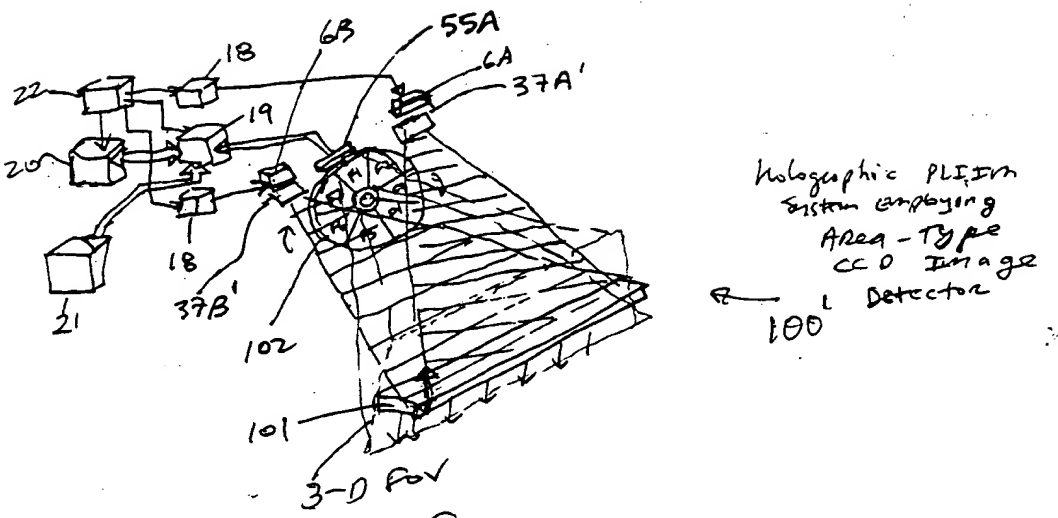

18
6B
55A
CA
37A'
22
19
20
18
37B'
21
102
101
3-D FOV
Holographic PLIIM System employing Area-Type CCD Image Detector
100

FIG. 8A

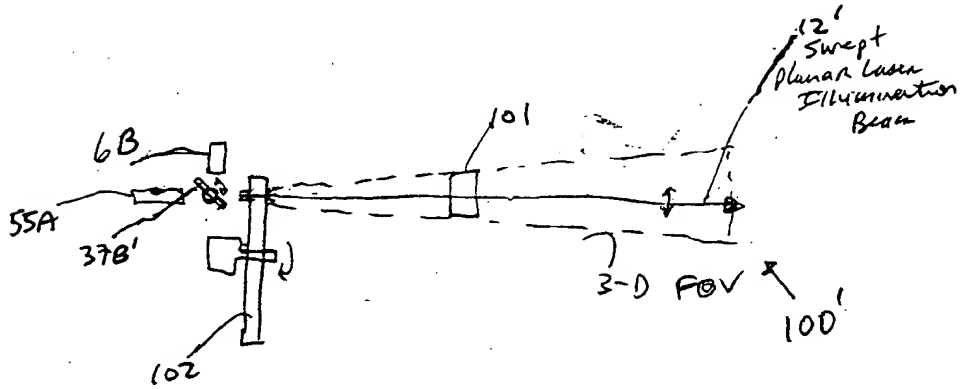

12'
Swept Planar Laser Illumination Beam
101
6B
55A
37B'
102
3-D FOV
100'

FIG. 8B

1-D CCD SCANNER EMBODIMENT

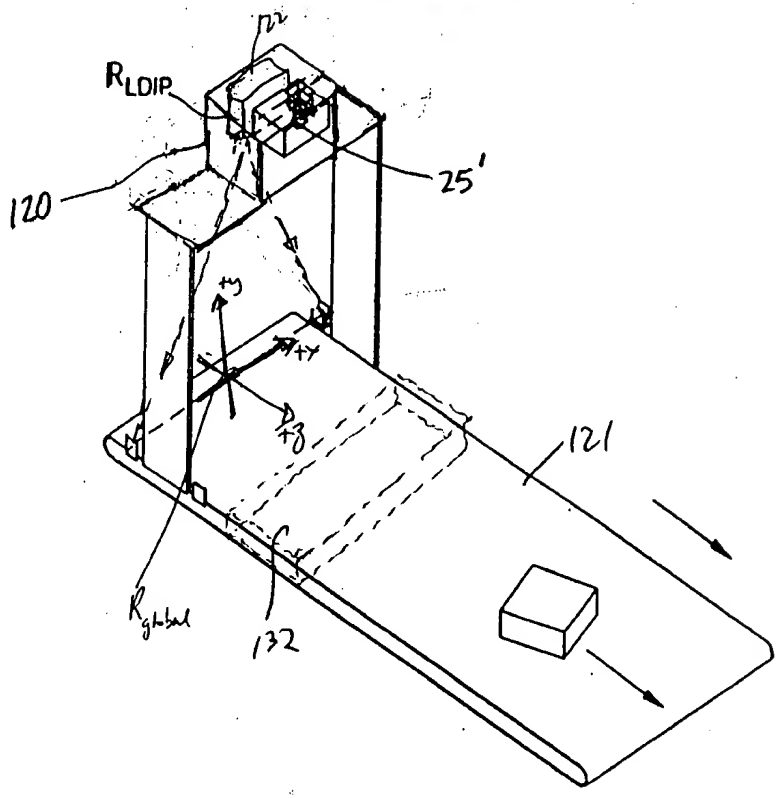


FIG. 9

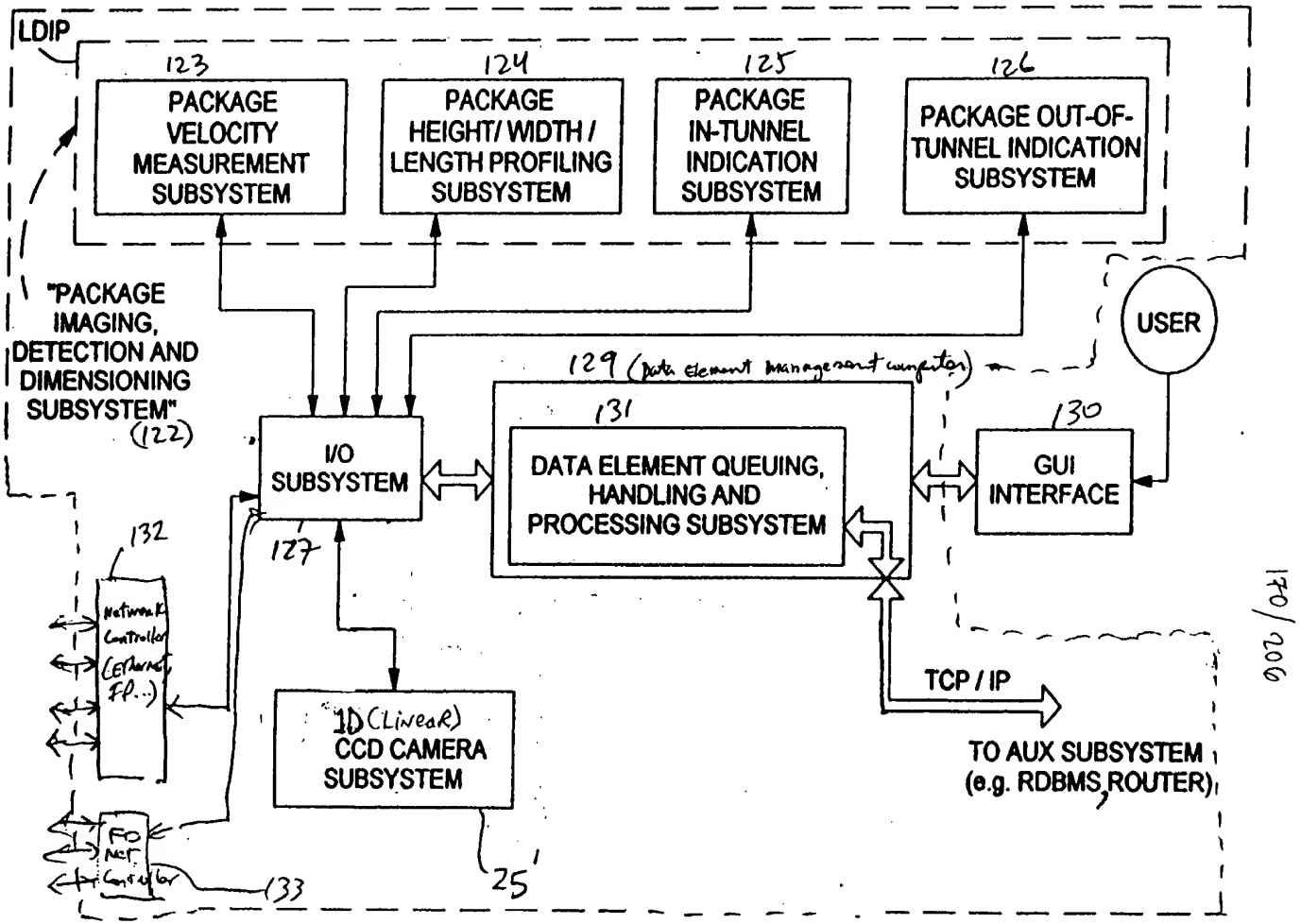


FIG. 10

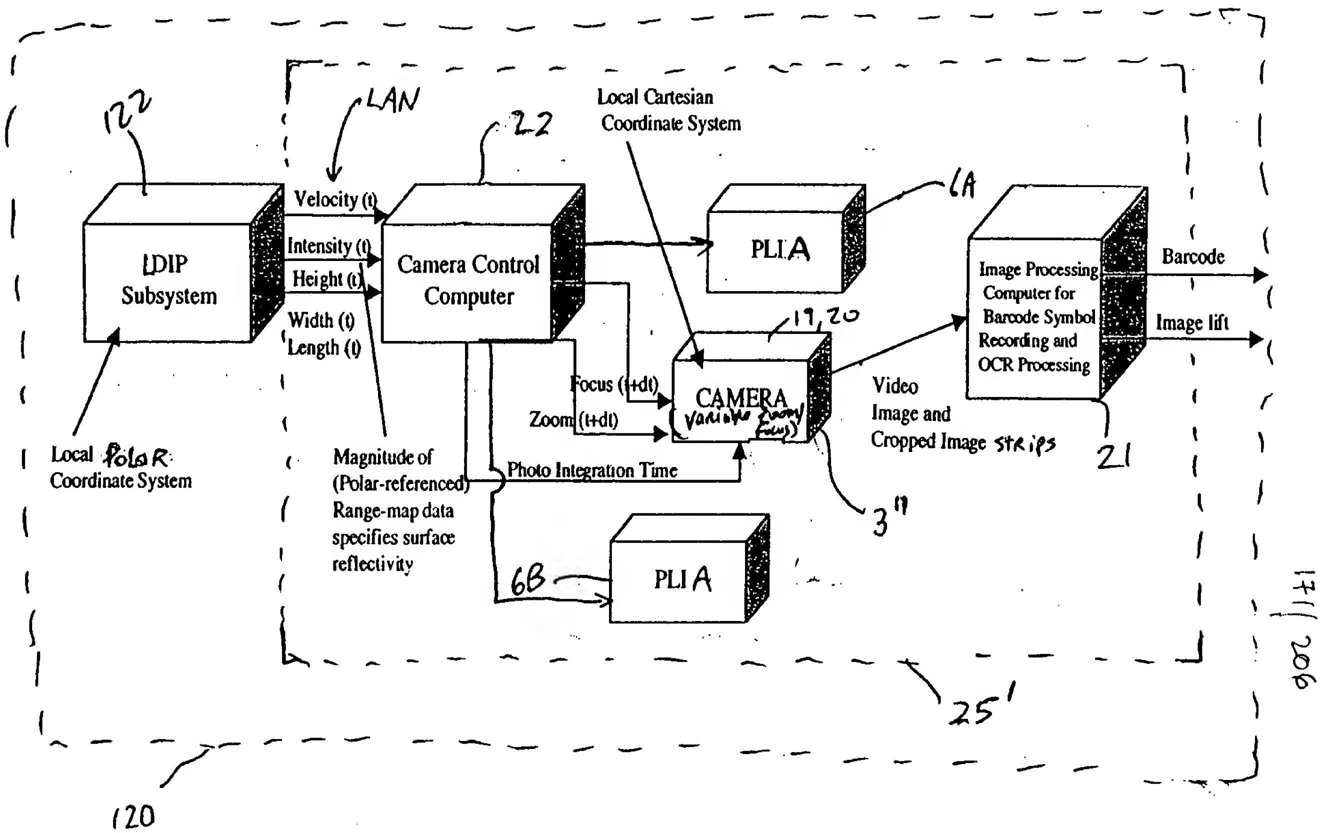


FIG. 11

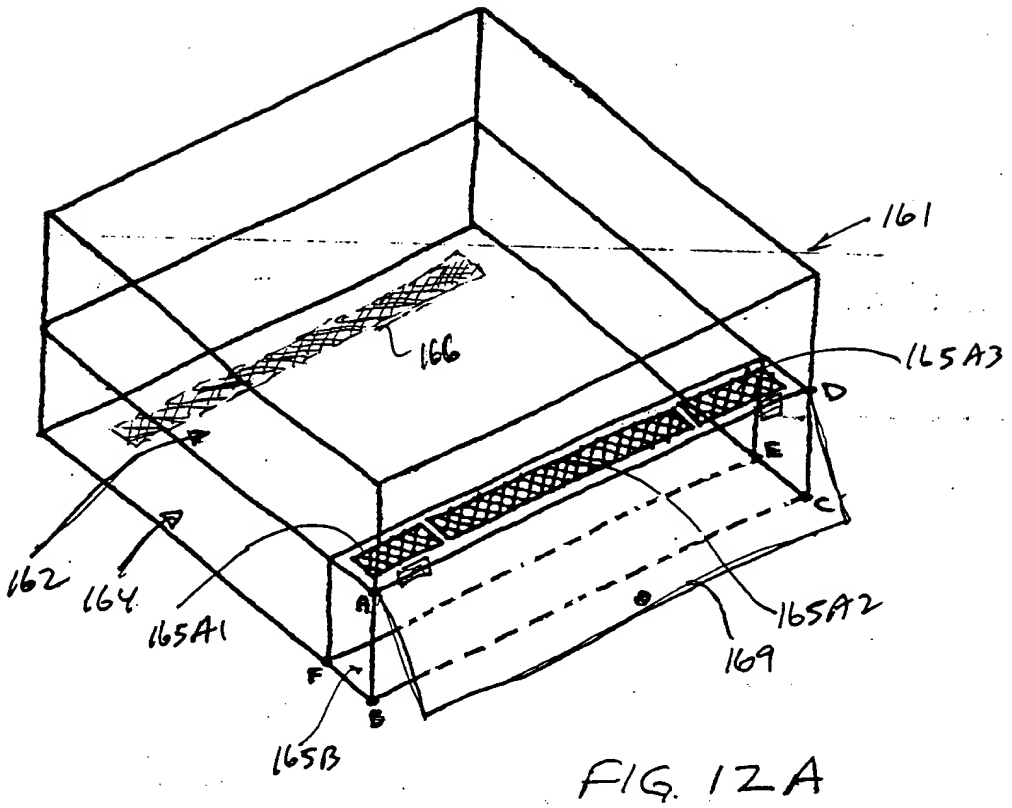


FIG. 12A

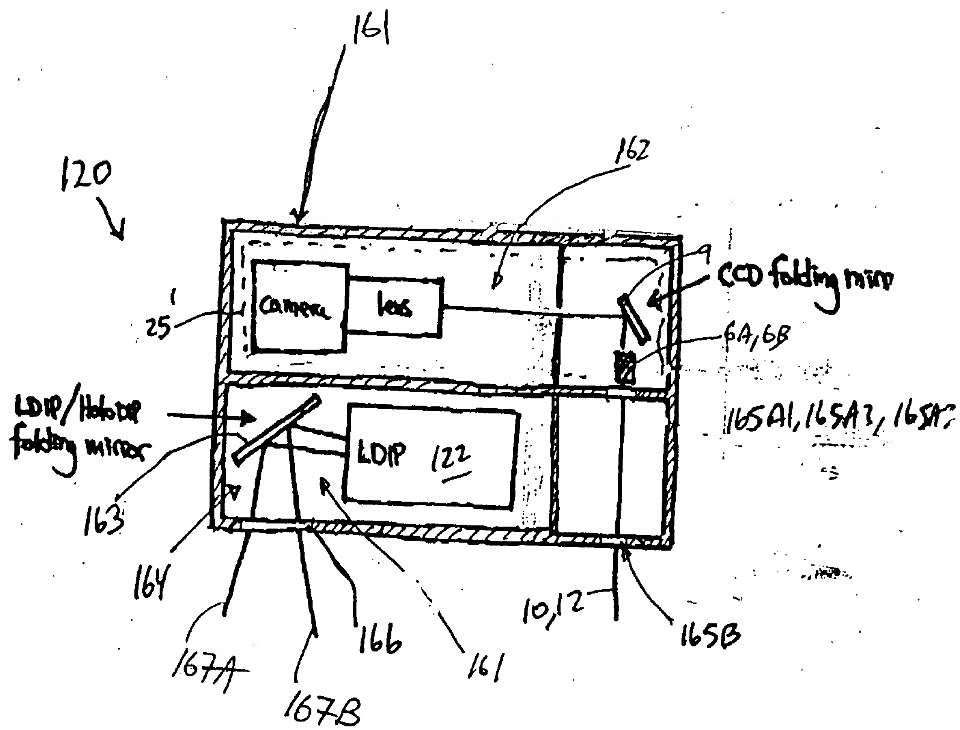

161
120
162
camera
lens
25
CCD folding mirr
6A,6B
165A1, 165A2, 165A3
LDIP/HoloDIP
folding mirror
LDIP 122
163
164
167A
167B
166
161
10,12
165B

FIG. 12B

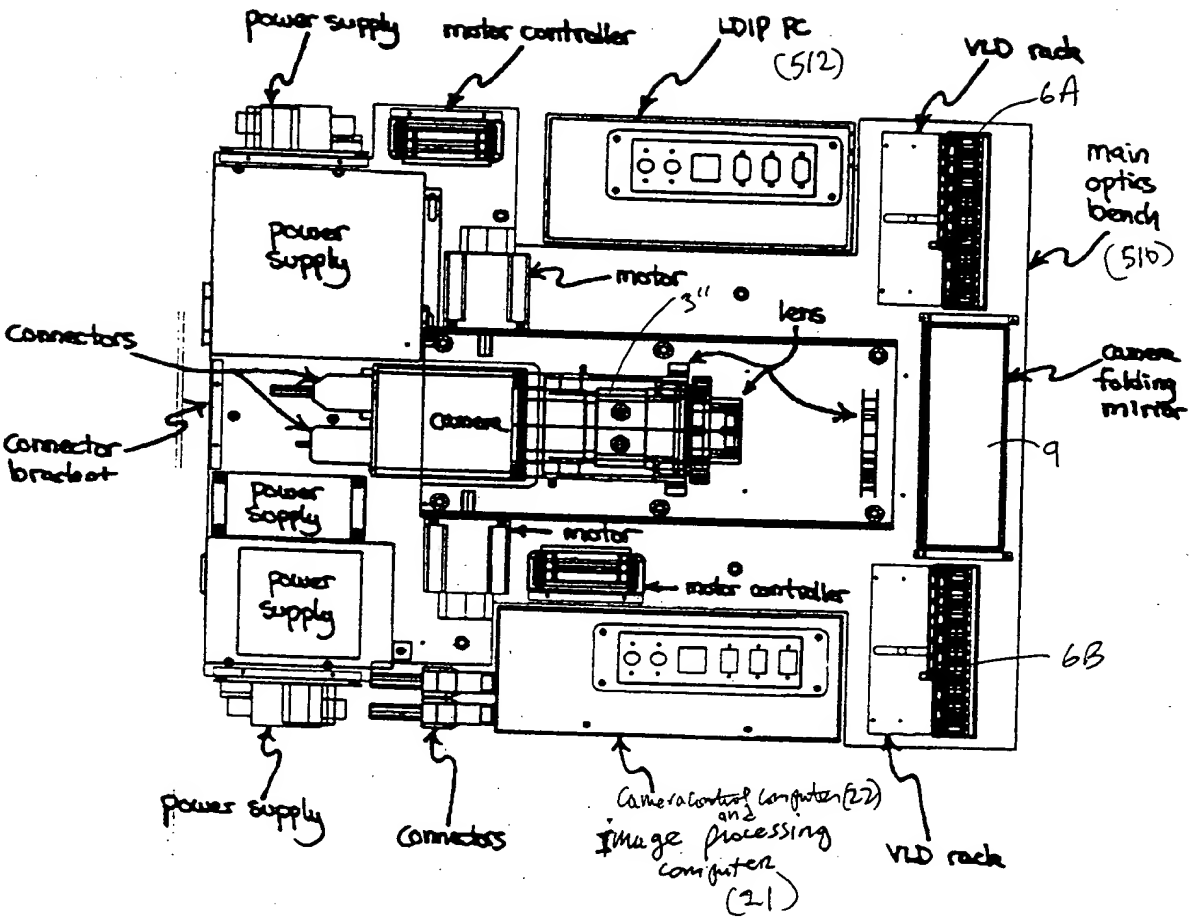

power supply
motor controller
LDIP PC
(512)
VLD rack
6A
main optics bench
(510)
power supply
motor
3"
lens
connectors
camera
camera folding mirror
connector bracket
9
power supply
motor
power supply
motor controller
6B
power supply
connectors
Camera control computer (22) and image processing computer (21)
VLD rack

FIG. 12C

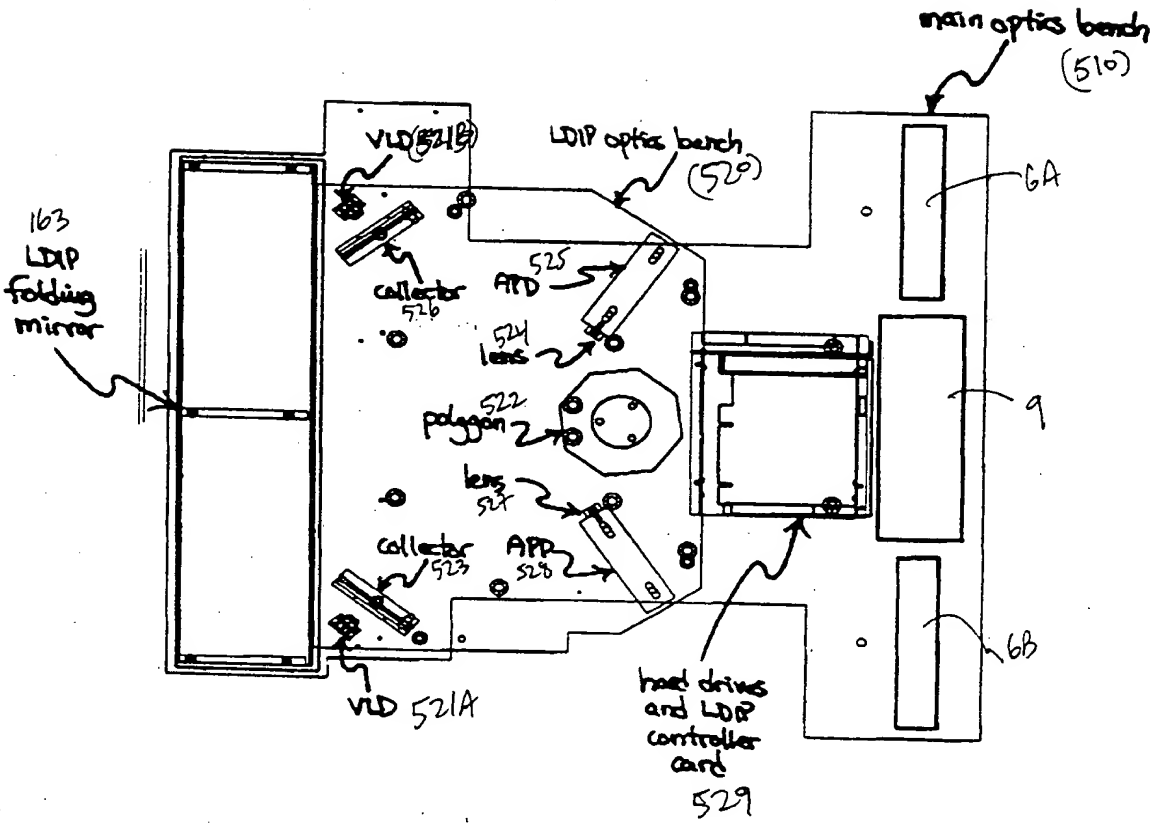
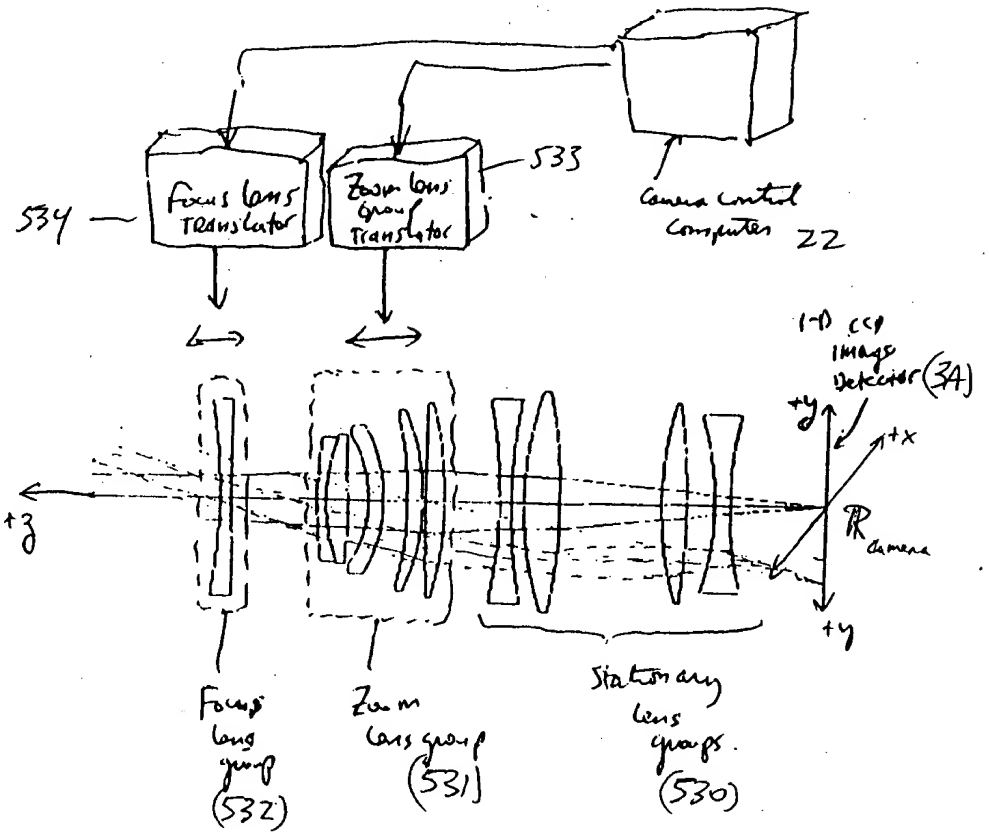

main optics bench
(510)
VLD(521B)
LDIP optics bench
(520)
6A
163
LDIP
folding
mirror
collector
526
APD
525
lens
524
polygon
522
9
lens
527
collector
523
APD
528
6B
VLD 521A
head drives
and LDIP
controller
card
529

FIG. 12D



(main optics)
(Lens groups)

FIG. 12E

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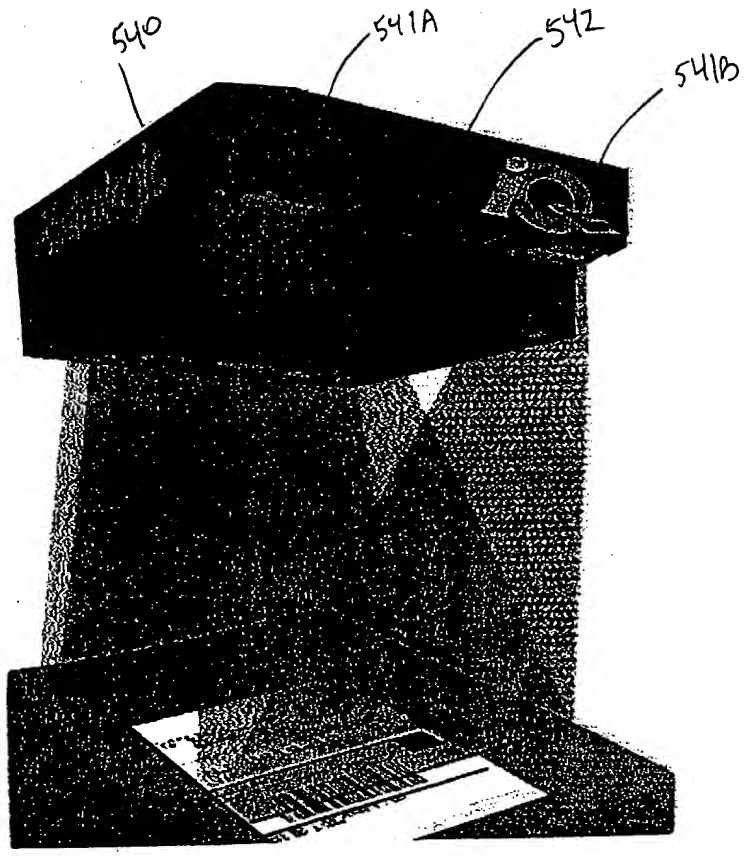

FIG. 13A

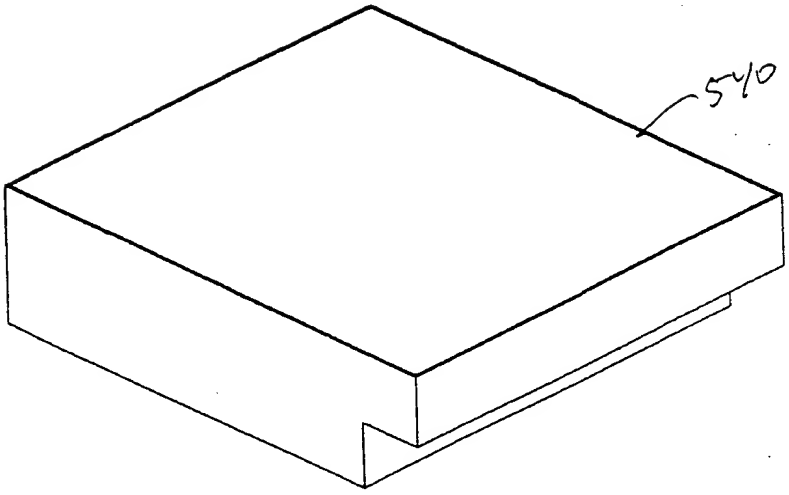

FIG. 13B

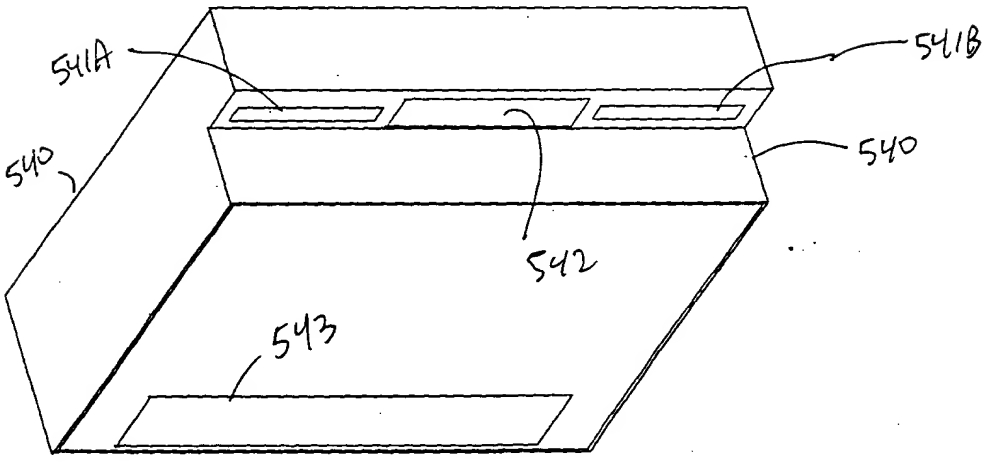

FIG. 13C

PLLIM-BASED PACKAGE IDENTIFICATION AND DIMENSIONING (PID) SYSTEM

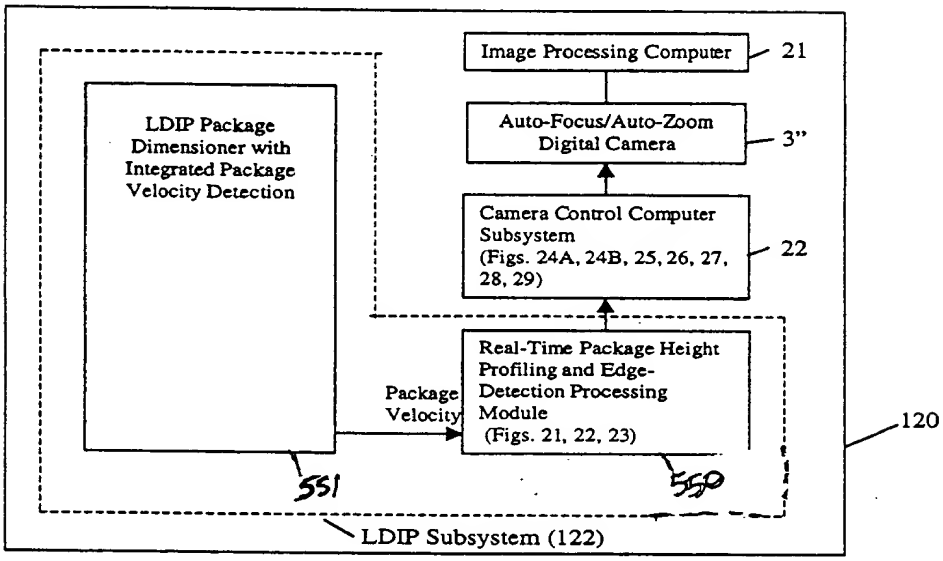

FIG. 14

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LDIP REAL-TIME PACKAGE HEIGHT PROFILE AND EDGE DETECTION METHOD

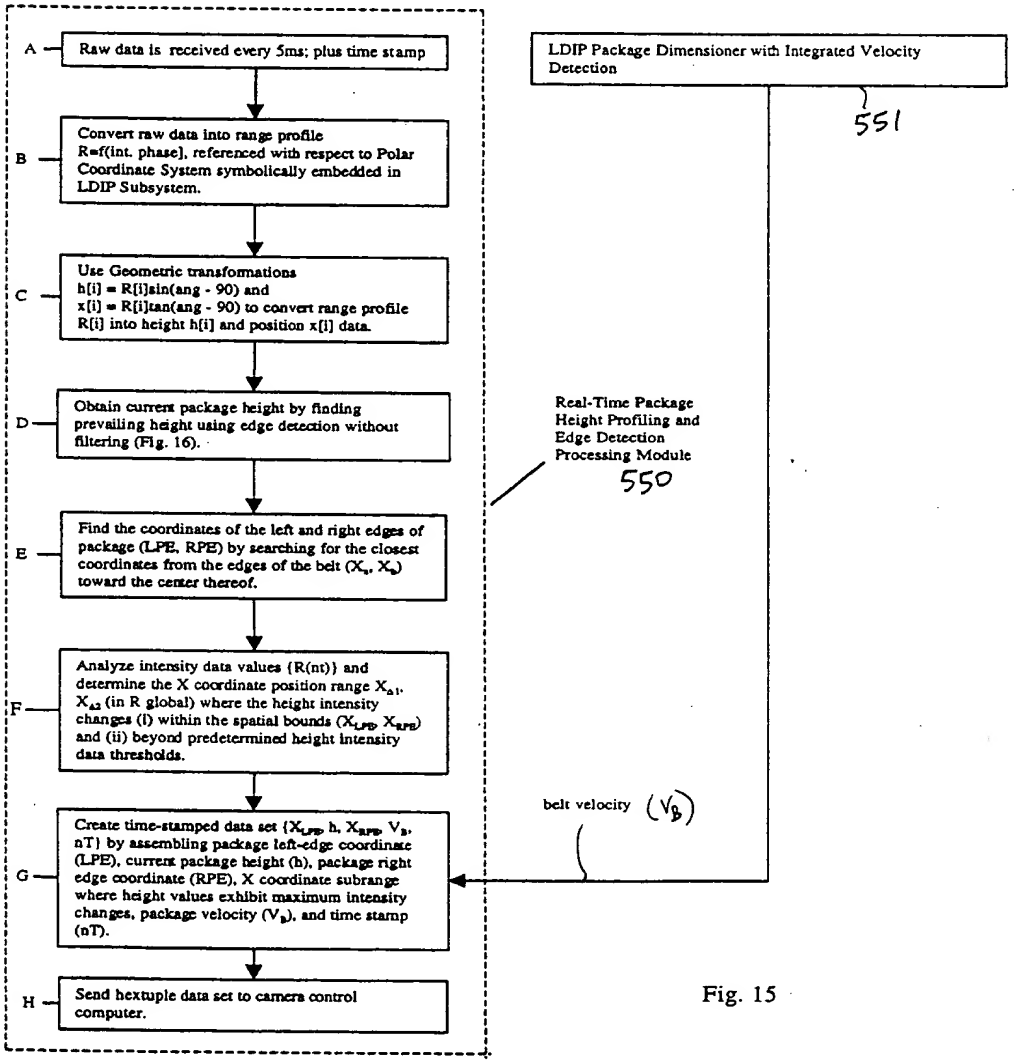
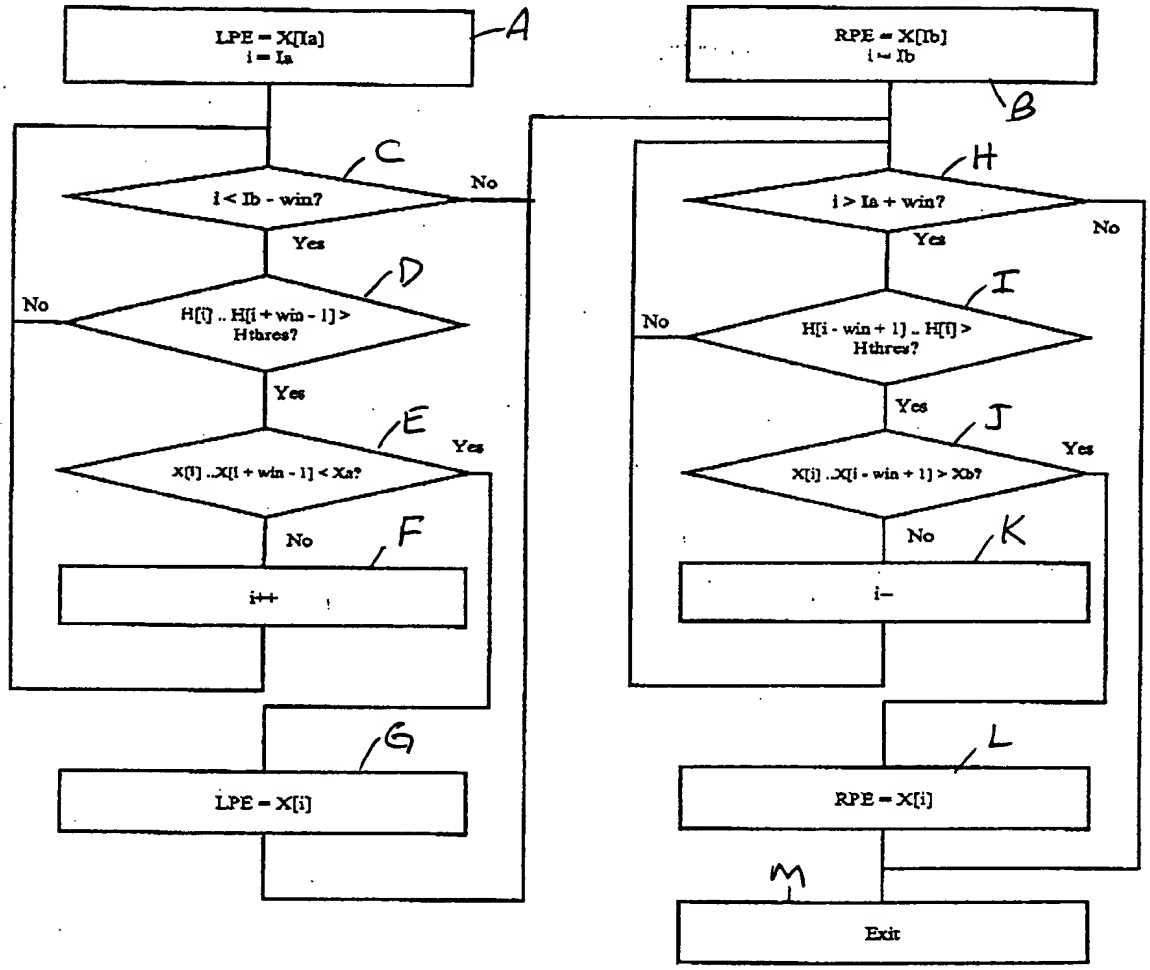


Fig. 15

LDIP Real Time Package Edge Detection



Xa = location of belt left edge; Xb = location of belt right edge
Ia = belt edge edge pixel; Ib = belt right edge pixel
LPE = Left package edge; RPE = Right package edge
H[] = Pixel height array; X[] = Pixel location array
win = package detection window

FIG. 16

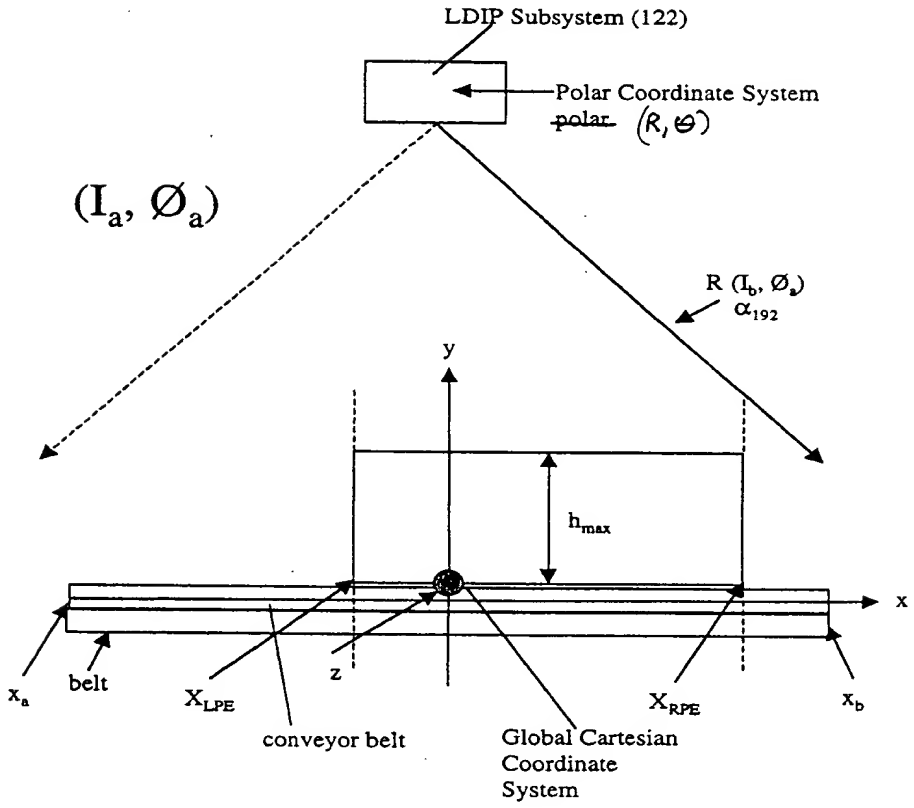

LDIP Subsystem (122)
Polar Coordinate System
polar (R, θ)
(I_a, Ø_a)
R (I_b, Ø_b)
α_192
y
h_max
x
x_a
belt
X_LPE
z
conveyor belt
Global Cartesian
Coordinate
System
X_RPE
x_b

Fig. 17

INFORMATION MEASURED AT SCAN ANGLES BEFORE COORDINATE TRANSFORMS

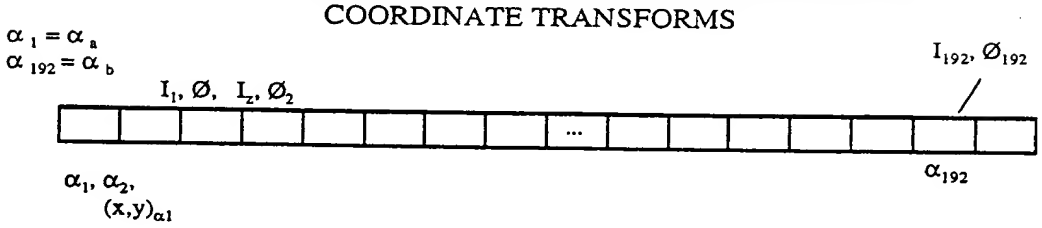


Fig. 17A

RANGE AND POLAR ANGLE MEASURES TAKEN AT SCAN ANGLE α BEFORE COORDINATE TRANSFORMS

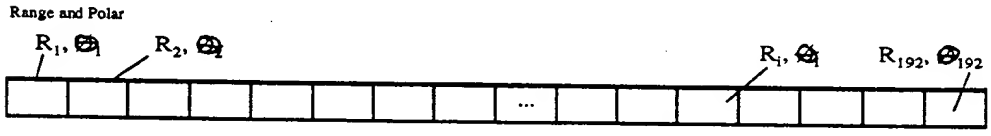


Fig. 17B

MEASURED PACKAGE HEIGHT AND POSITION VALUES AFTER COORDINATE TRANSFORMS

H [ ]
Input height after coordinate transforms

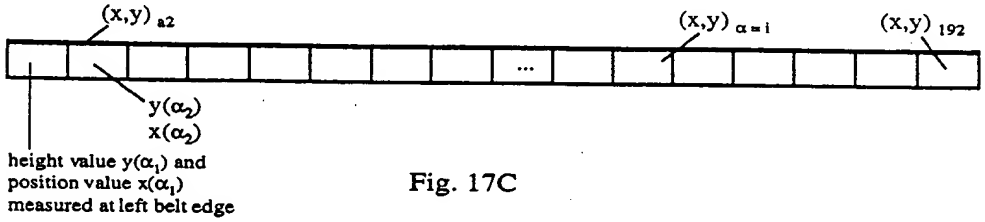


Fig. 17C

CAMERA CONTROL PROCESS CARRIED OUT WITHIN THE CAMERA CONTROL SUBSYSTEM OF EACH OBJECT ATTRIBUTE ACQUISITION AND ANALYSIS SYSTEM

560

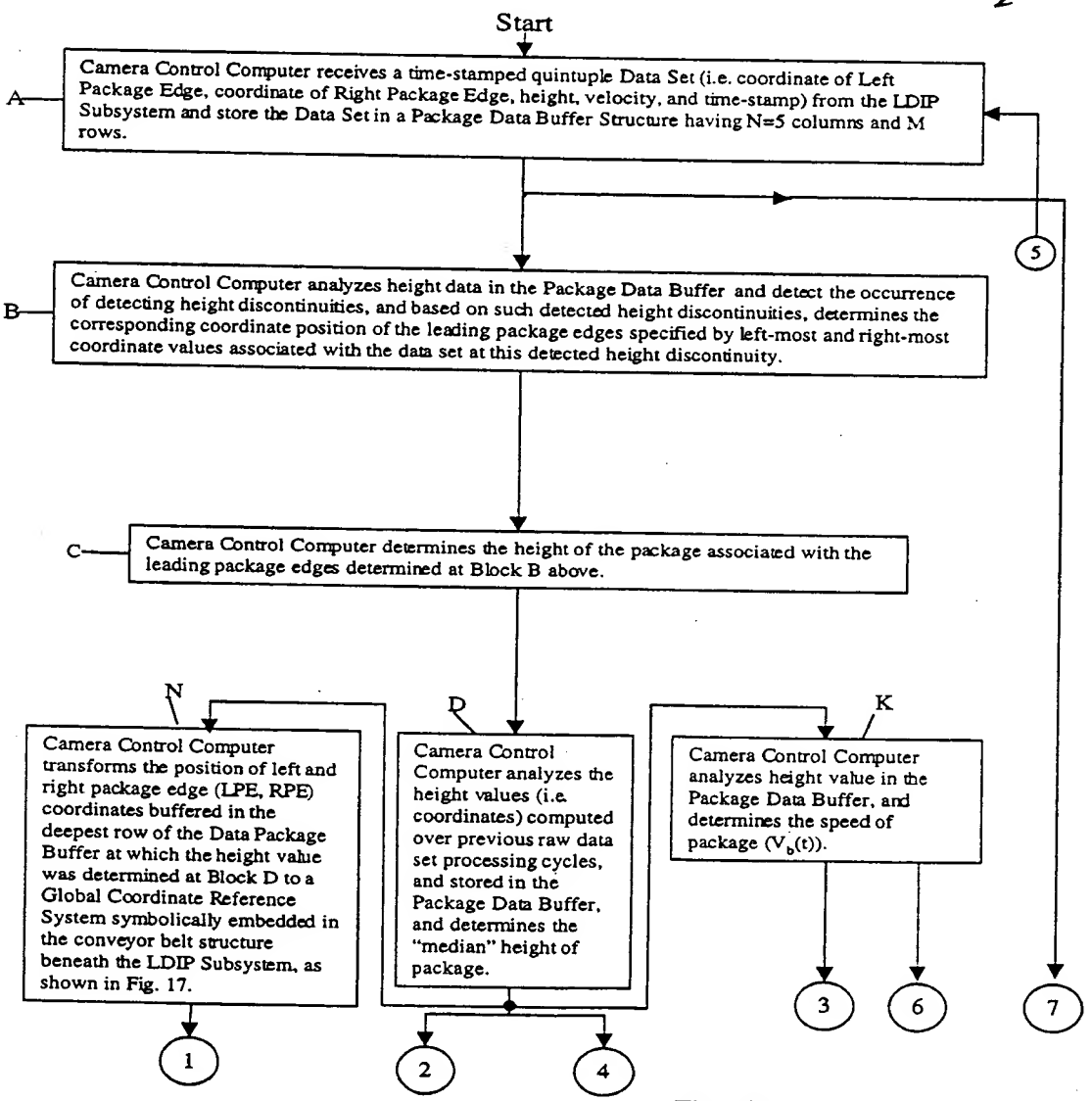


Fig. 18A

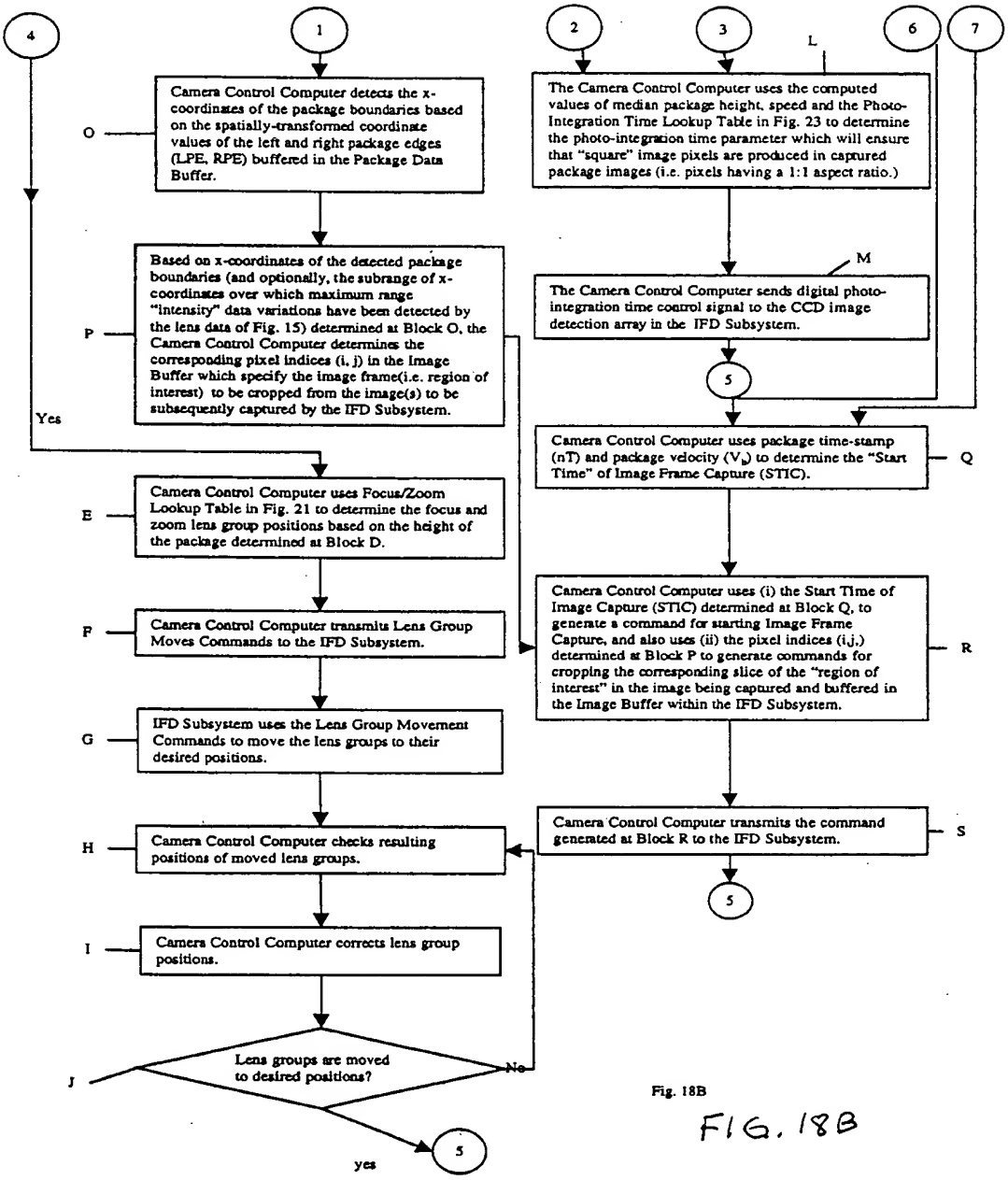


Fig. 18B

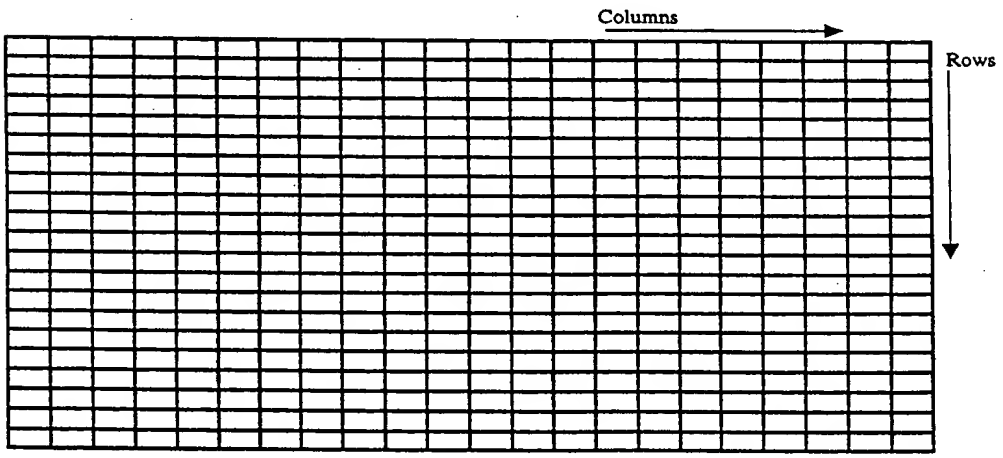
FIG. 18B

x coordinate subrange where maximum range "intensity" variations have been detected

Left Package Edge (LDE)	Package Height (h)	Right Package Edge (RPE)	Package Velocity	Time-stamp (nT)	
					Row 1
					Row 2
					Row 3
					Row 4
					Row 5
					Row M

Package Data Buffer (FIFO)

Fig. 19



Camera Pixel Data Buffer
pixel indices (i,j)

Fig. 20

Zoom and Focus Lens Group position
Look-up TABLE

Distance from Camera H (mm)	Zoom group distance (mm) Y (Zoom)	Focus group distance (mm) Y (Focus)
1000	21.57489228	2.47E-05
1100	19.38089696	10.99009783
1200	17.10673434	20.65783177
1300	14.77137314	29.10917002
1400	12.39153565	36.47312595
1500	9.979114358	42.87845436
1600	7.540639114	48.44003358
1700	5.078794775	53.25495831
1800	2.595989366	57.40834303
1900	0.099972739	60.98883615

(use interpolation techniques for walking distances between listed points in table)

FIG. 21

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* Note: the focal distance & zoom (eff. focal length) of camera lens are coupled (inter-dependent) in this commercial embodiment.
Camera has a
* fixed aperture F56

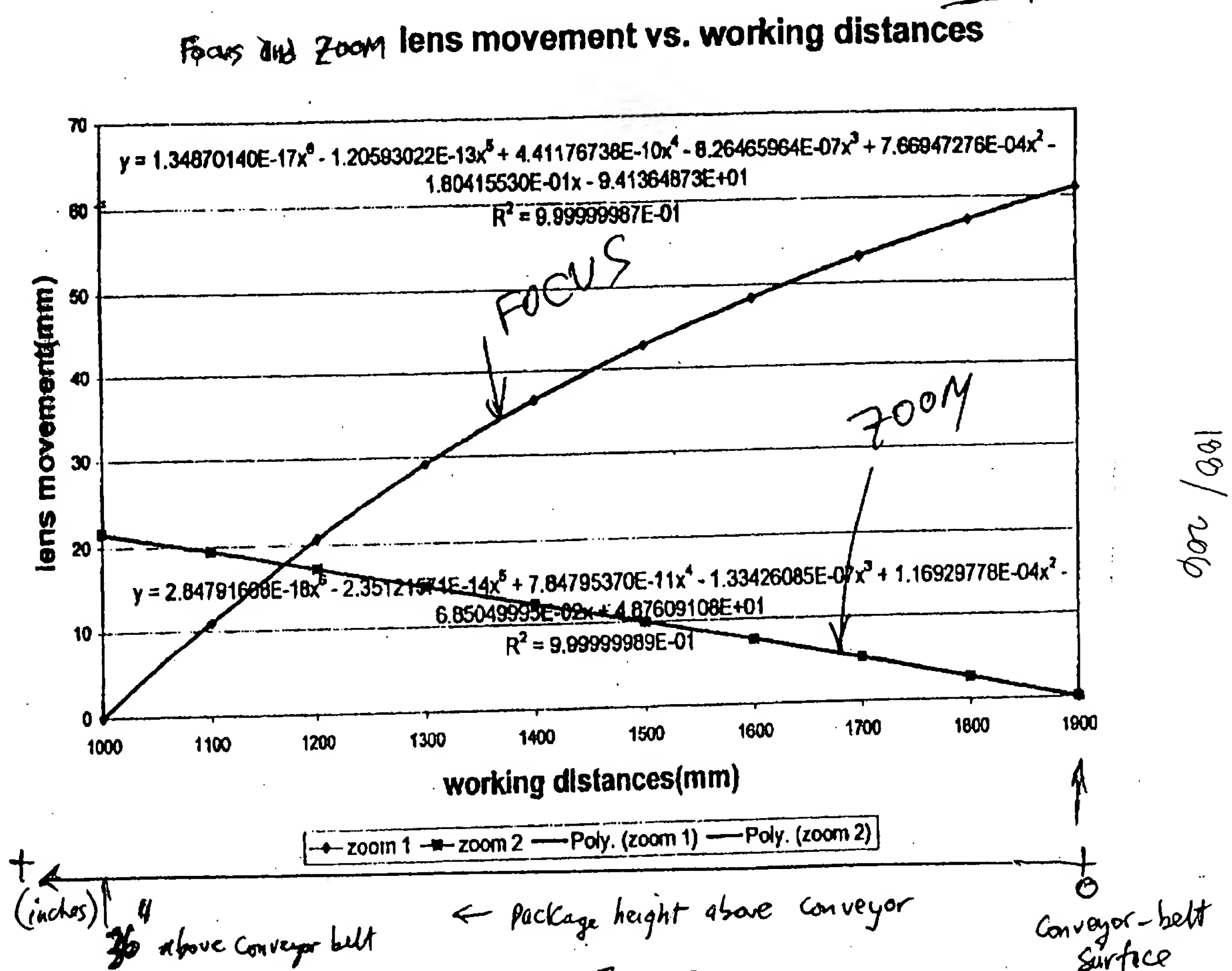


FIG. 22

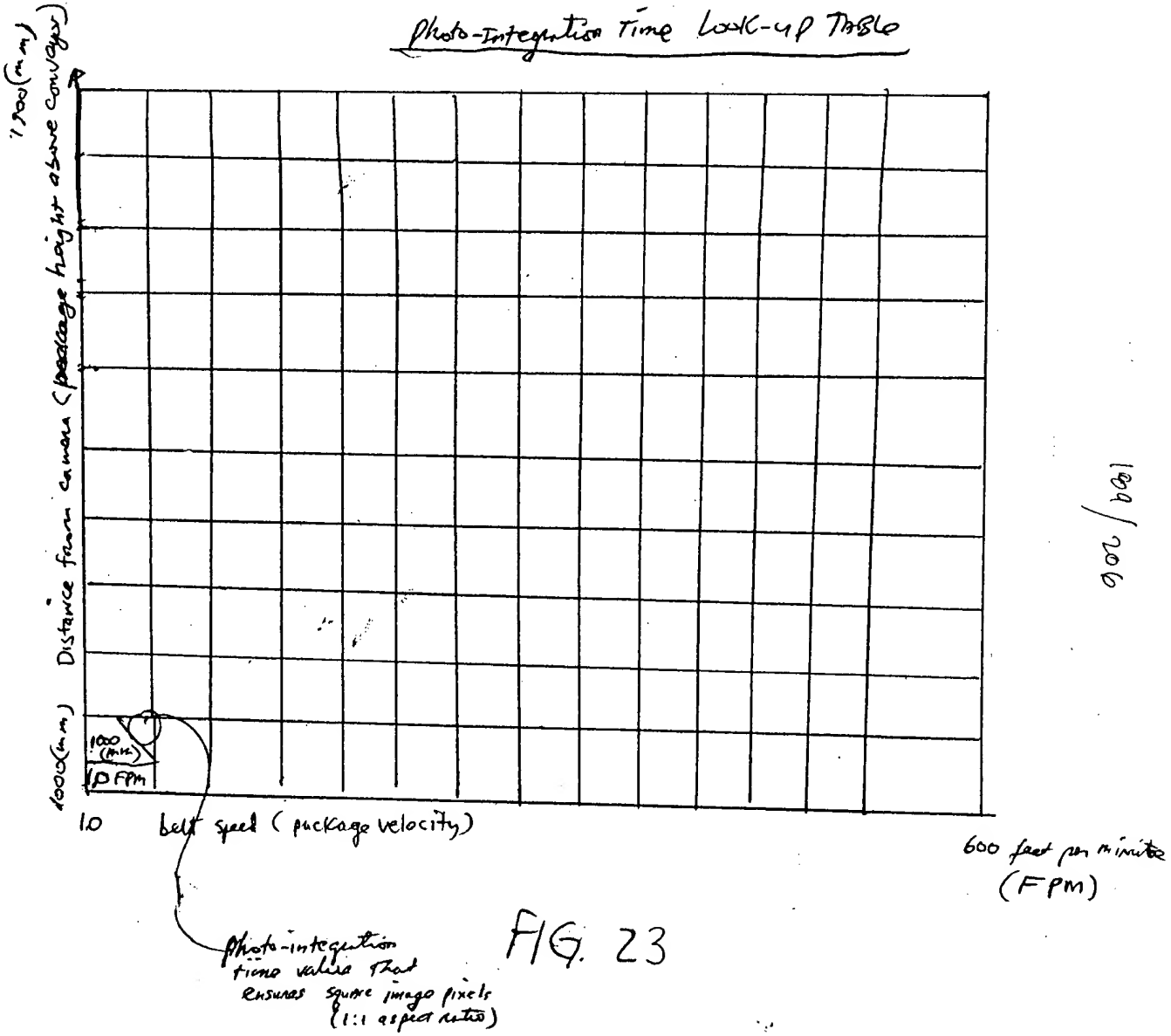


Photo-Integration Time Look-up Table
1200(mm)
Distance from camera (package height above conveyor)
1000(mm)
100 (mm)
10 FPM
10
belt speed (package velocity)
600 feet per minute (FPM)
Photo-integration time value that ensures square image pixels (1:1 aspect ratio)

FIG. 23

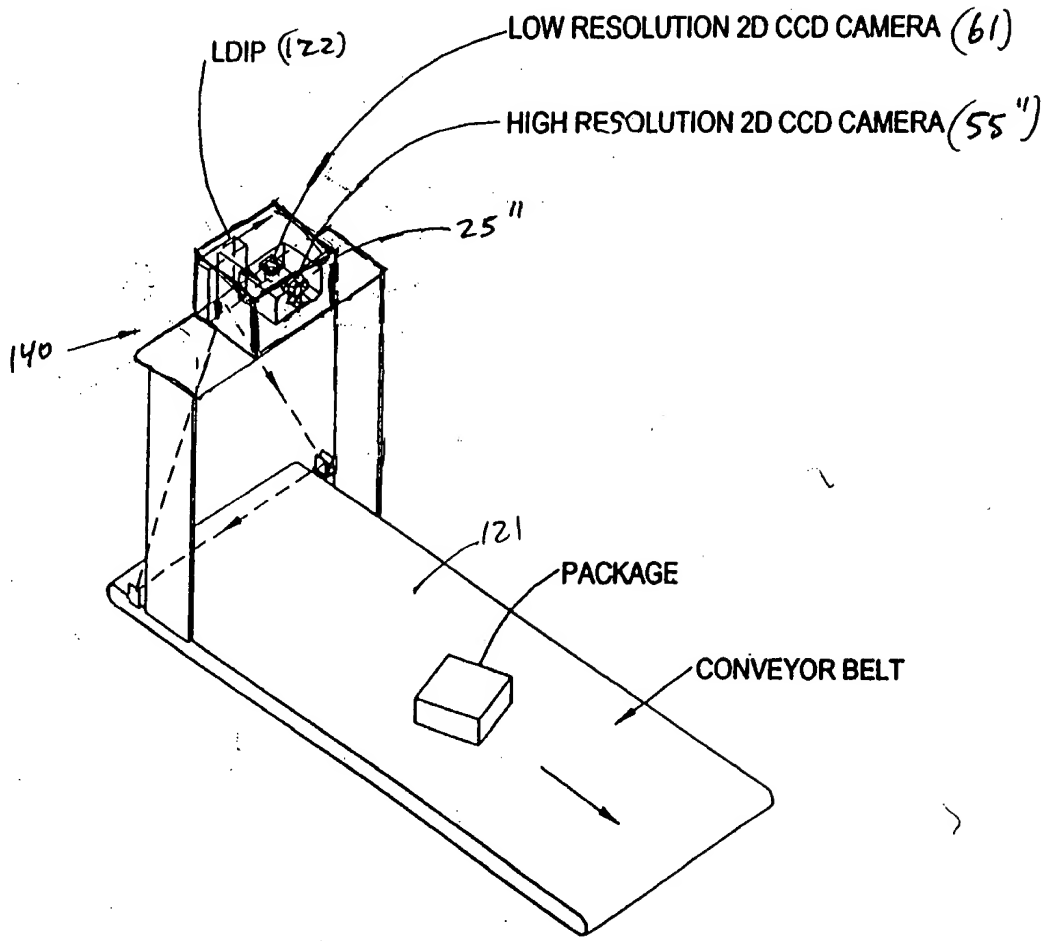
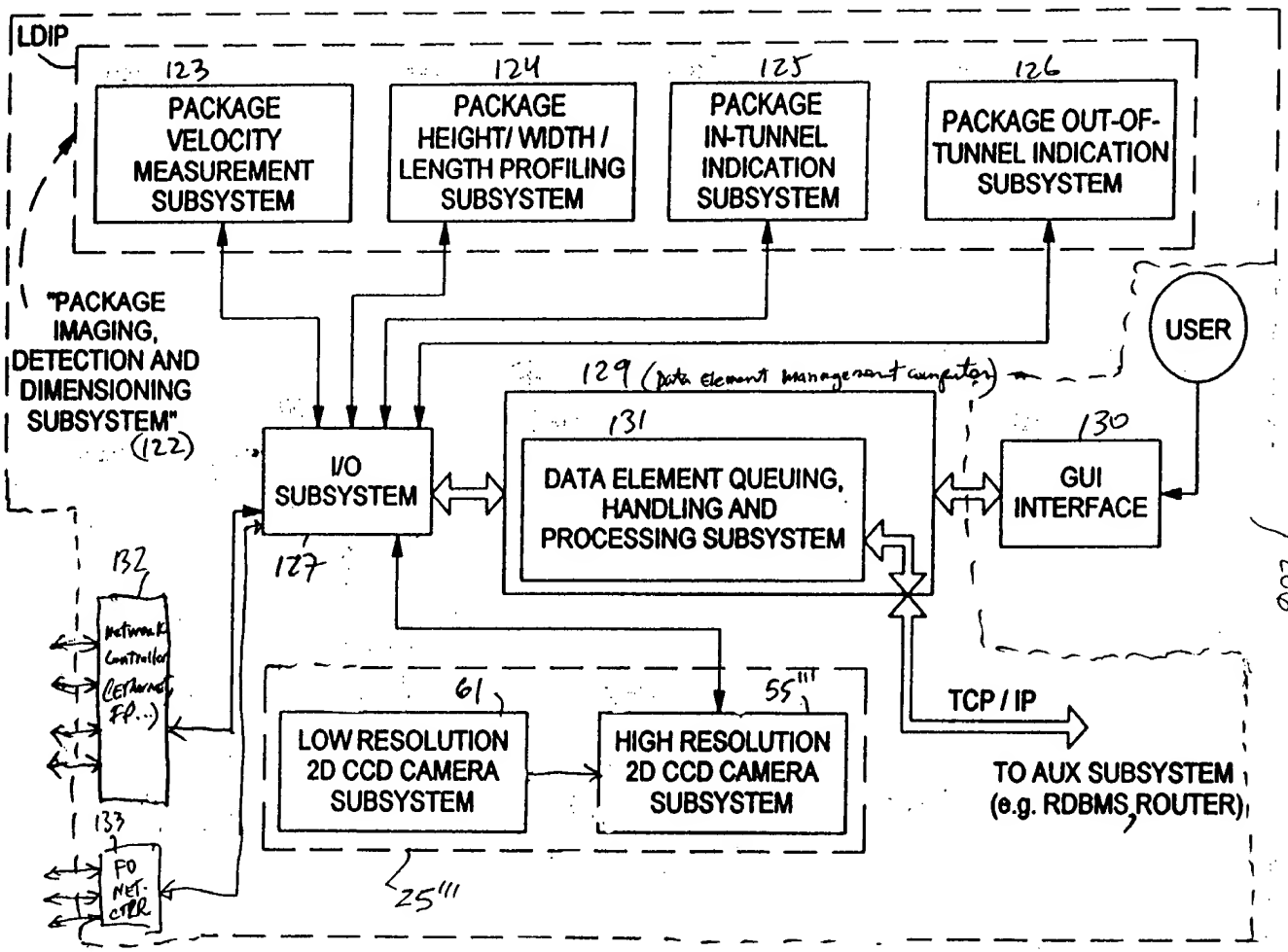


FIG 24



140

FIG.25

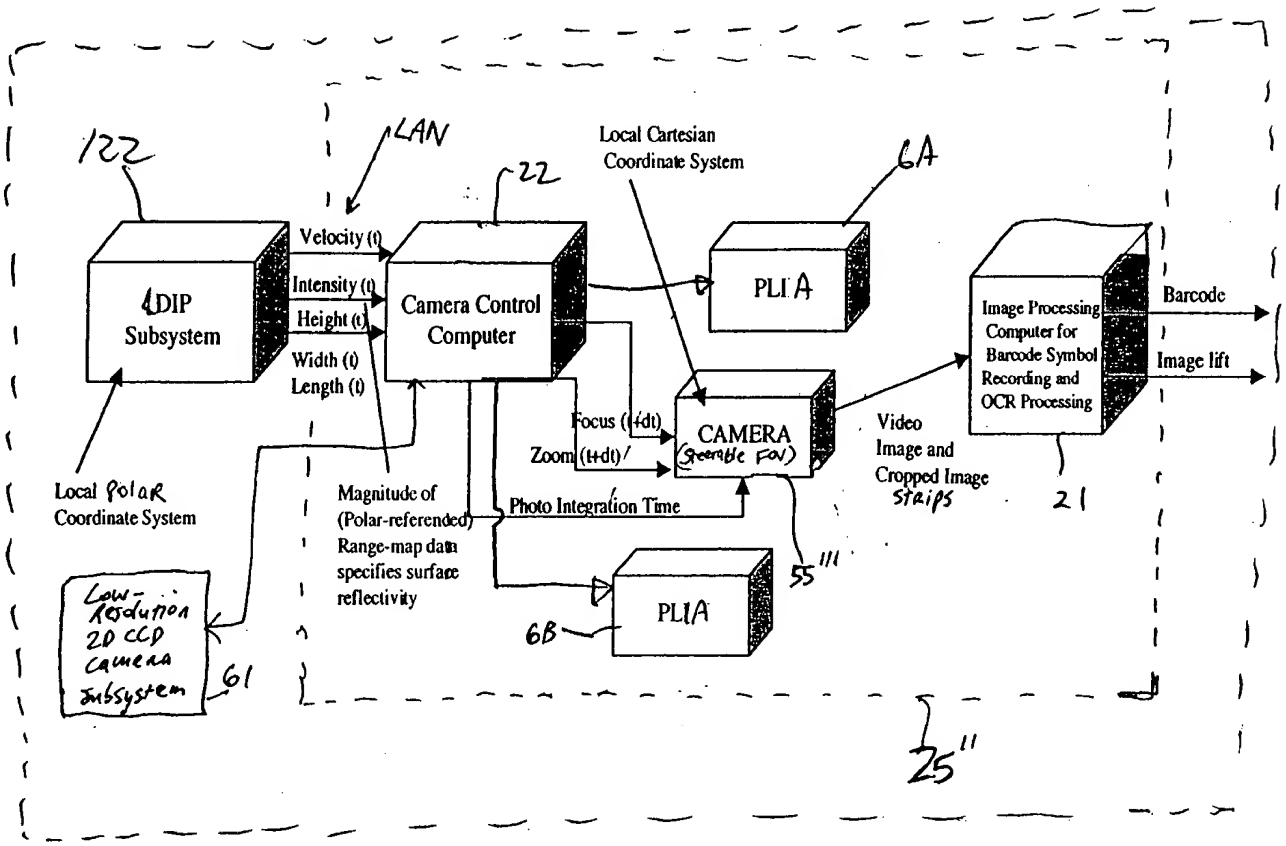


FIG. 26

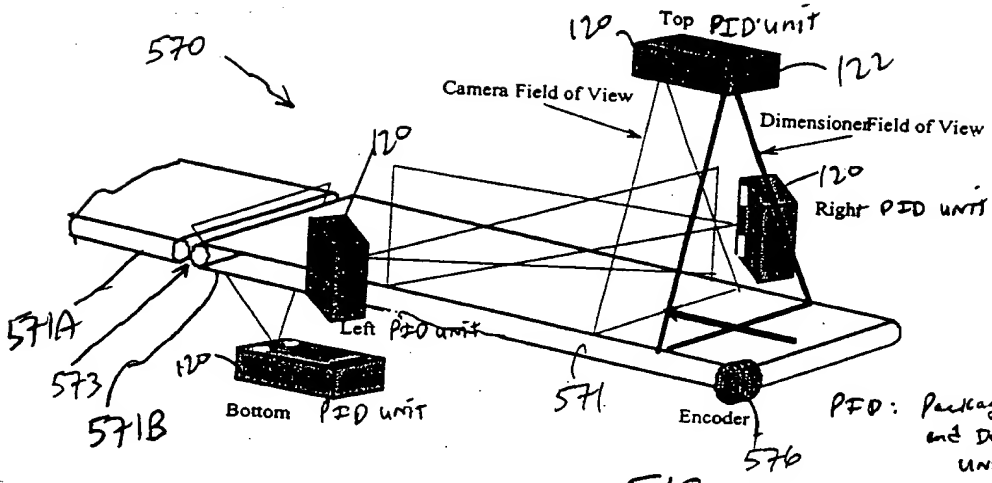

570
120
Top PID unit
122
Camera Field of View
Dimensioner Field of View
120
Right PID unit
120
Left PID unit
571A
573
571B
120
Bottom PID unit
571
Encoder
576
PID: Package Identification and Dimensioning Unit

FIG. 27

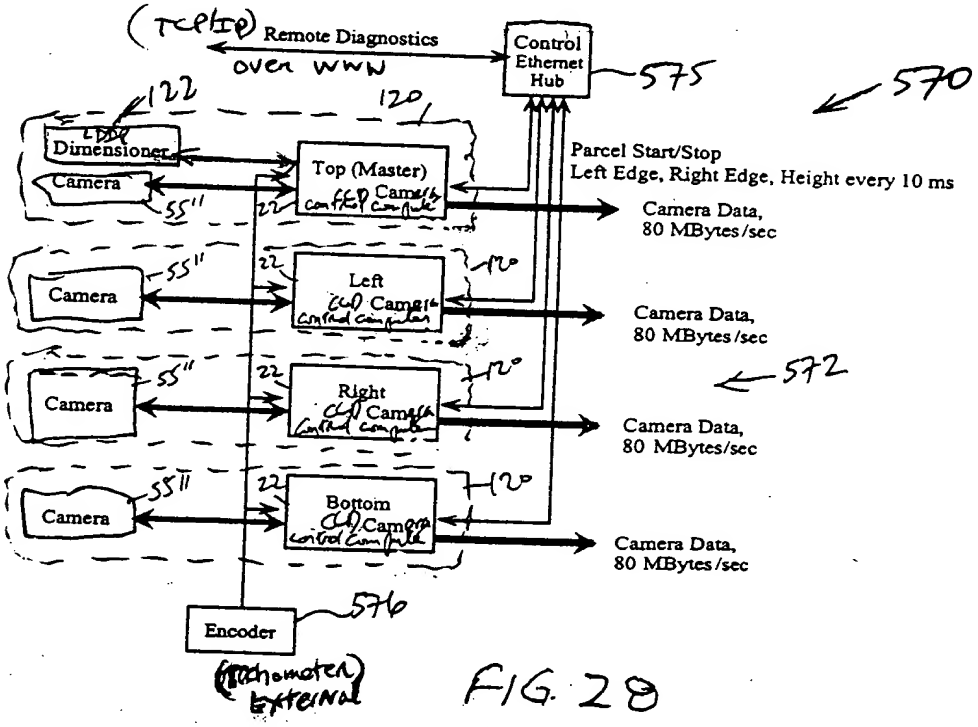

(TCP/IP) Remote Diagnostics over WWW
Control Ethernet Hub
575
570
122
120
LDDC Dimensioner
Camera
Top (Master) CCD Camera
55"
22
Parcel Start/Stop
Left Edge, Right Edge, Height every 10 ms
Camera Data, 80 MBytes/sec
Left CCD Camera
Camera Data, 80 MBytes/sec
572
Right CCD Camera
Camera Data, 80 MBytes/sec
Bottom CCD Camera
Camera Data, 80 MBytes/sec
Encoder
576
(Tachometer External)

FIG. 28

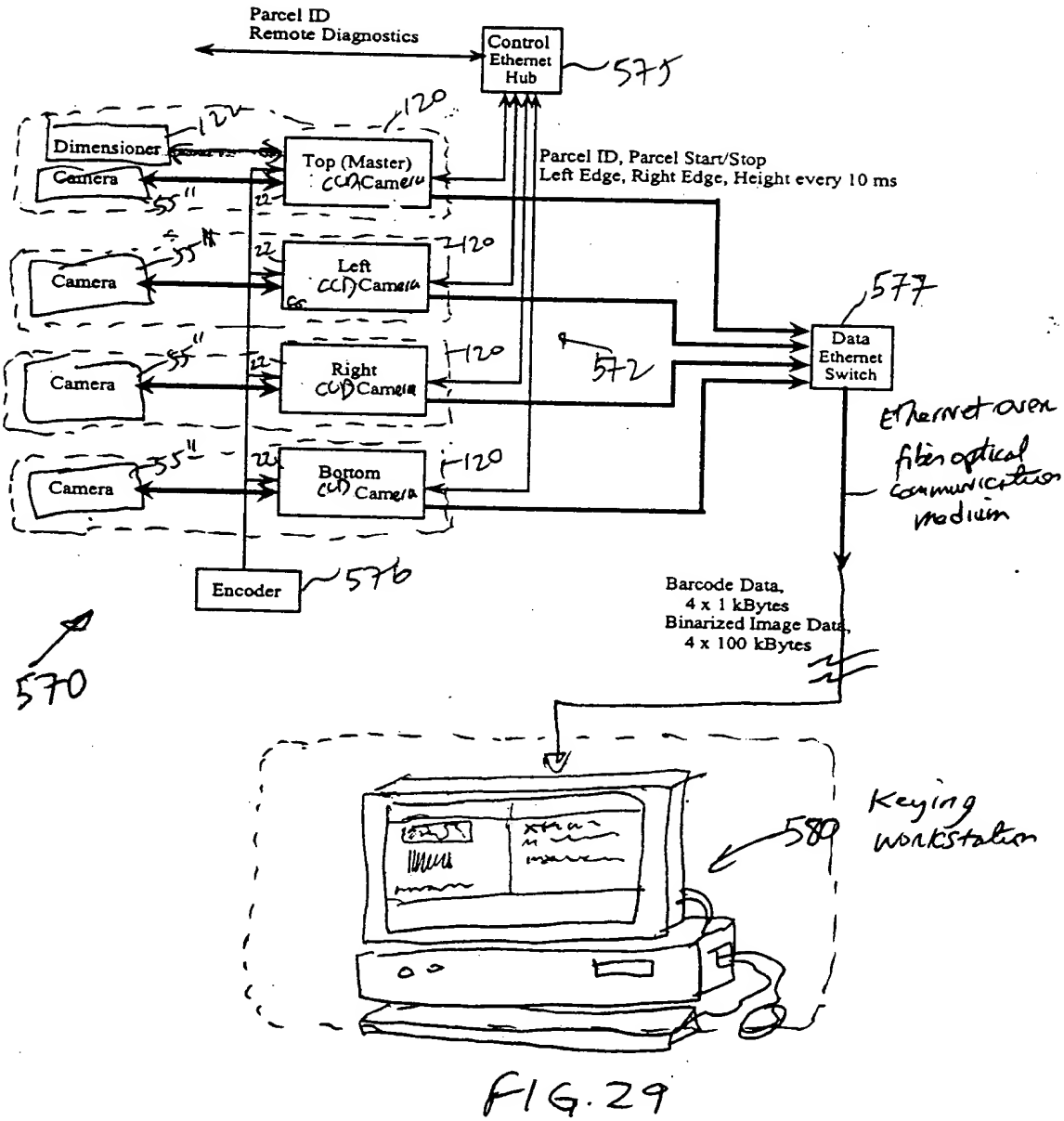

Parcel ID
Remote Diagnostics
Control Ethernet Hub
575
Dimensioner
Camera
Top (Master) CCD Camera
120
Parcel ID, Parcel Start/Stop
Left Edge, Right Edge, Height every 10 ms
Left CCD Camera
Right CCD Camera
Bottom CCD Camera
Data Ethernet Switch
577
572
Ethernet over fiber optical communication medium
Encoder
576
570
Barcode Data,
4 x 1 kBytes
Binarized Image Data,
4 x 100 kBytes
Keying Workstation
580

FIG. 29

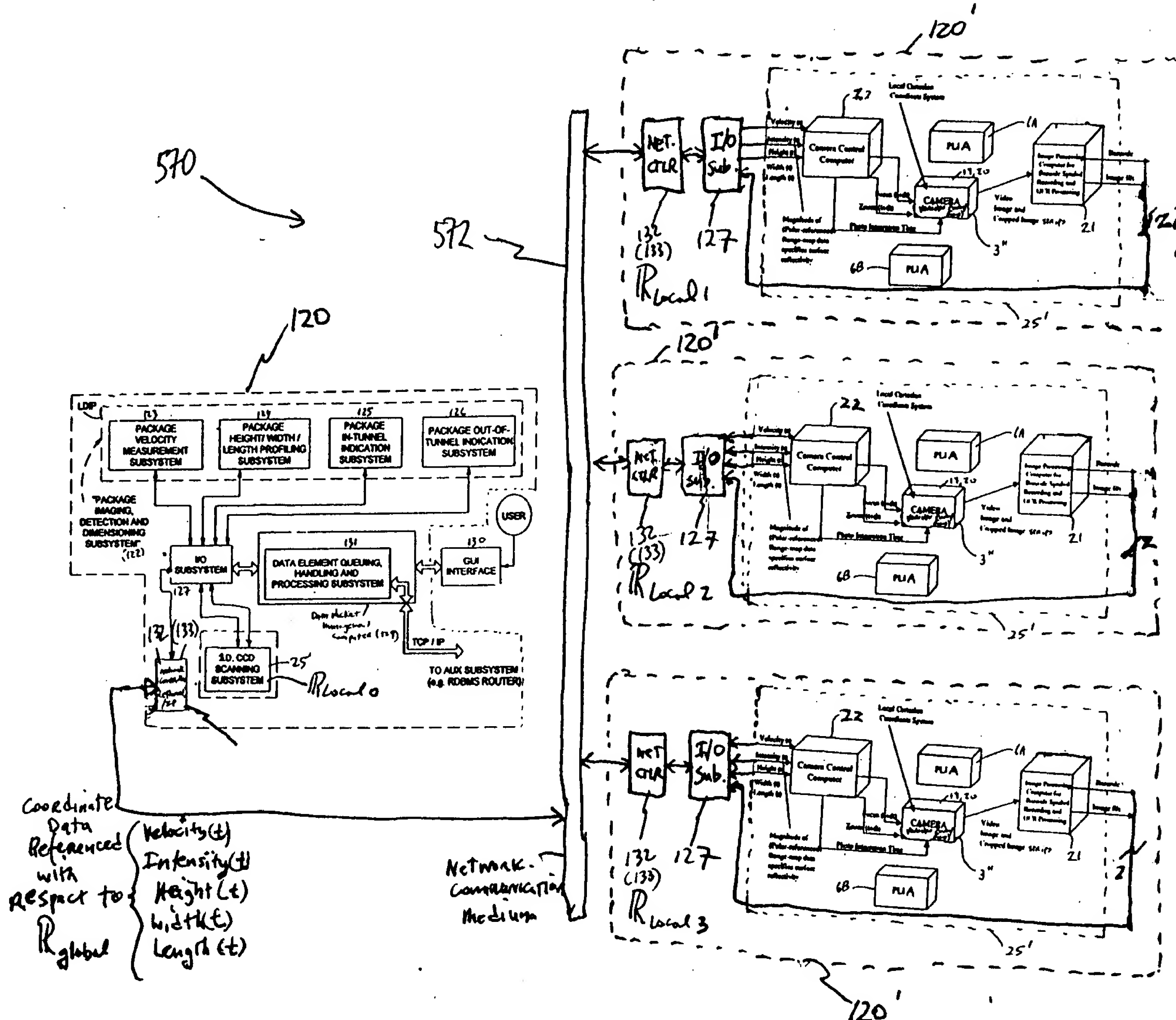

570
572
120
LDIP
PACKAGE VELOCITY MEASUREMENT SUBSYSTEM
PACKAGE HEIGHT/ WIDTH / LENGTH PROFILING SUBSYSTEM
PACKAGE IN-TUNNEL INDICATION SUBSYSTEM
PACKAGE OUT-OF-TUNNEL INDICATION SUBSYSTEM
"PACKAGE IMAGING, DETECTION AND DIMENSIONING SUBSYSTEM" (122)
I/O SUBSYSTEM
127
131
DATA ELEMENT QUEUING, HANDLING AND PROCESSING SUBSYSTEM
130
GUI INTERFACE
USER
TCP / IP
TO AUX SUBSYSTEM (e.g. RDBMS ROUTER)
1D. CCD SCANNING SUBSYSTEM
25
132
(133)
R Local 0
Coordinate Data Referenced with Respect to R global
Velocity (t)
Intensity (t)
Height (t)
Width (t)
Length (t)
Network Communication Medium
120'
NET. CTLR
I/O Sub.
132 (133)
127
R Local 1
R Local 2
R Local 3
22
Camera Control Computer
Local Cartesian Coordinate System
PLIA
1A
6B
CAMERA
3"
21
25'
Video Image and Cropped Image
Barcode
Image file
Photo Integration Time
Zoom Code
Velocity
Intensity
Height
Width
Length
2

FIG 30

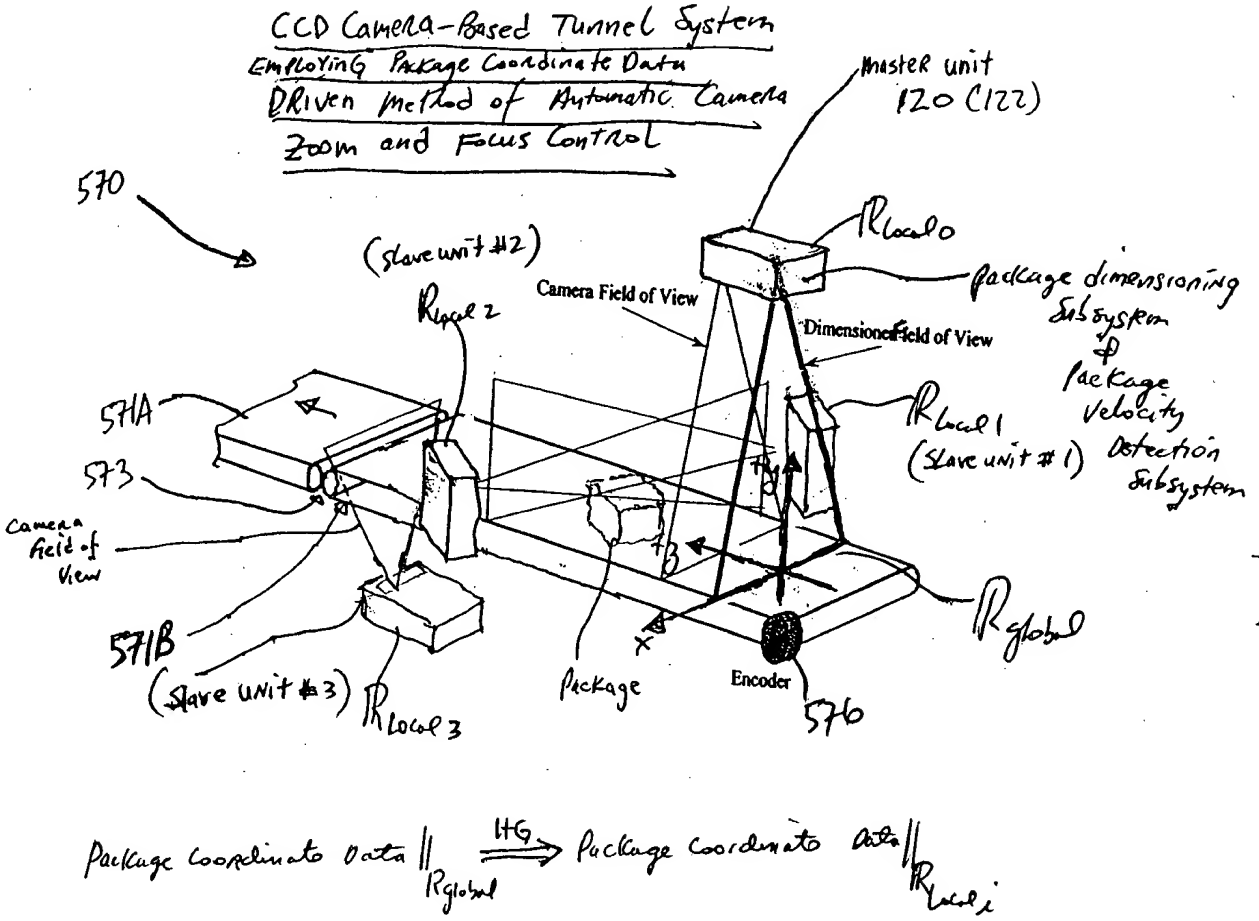


FIG.31

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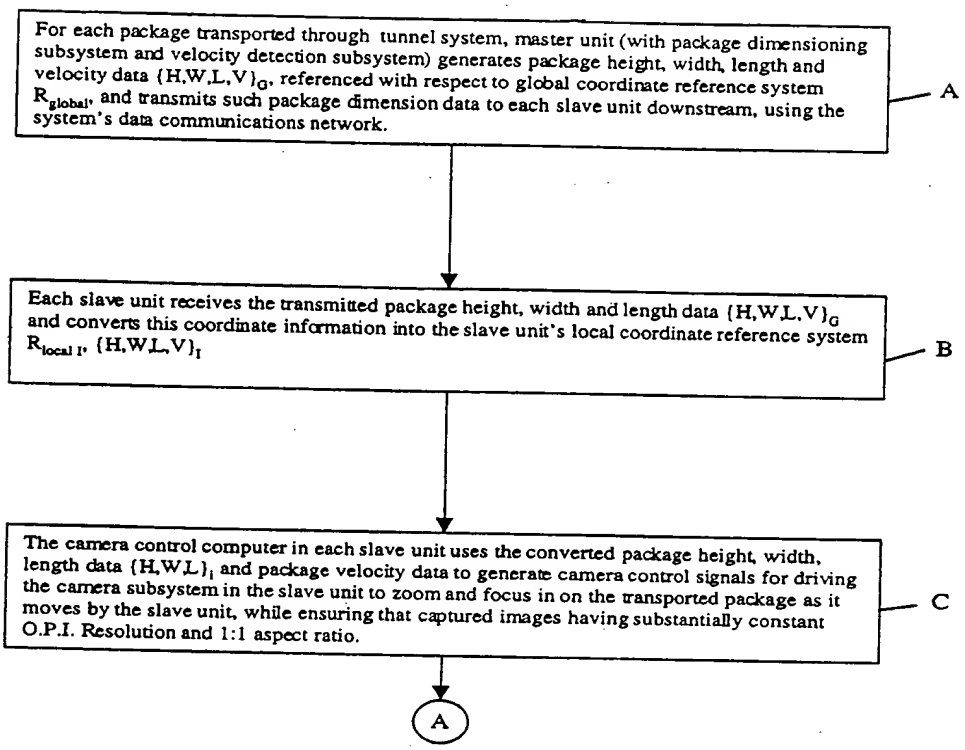

For each package transported through tunnel system, master unit (with package dimensioning subsystem and velocity detection subsystem) generates package height, width, length and velocity data $\{H,W,L,V\}_G$, referenced with respect to global coordinate reference system R_{global}, and transmits such package dimension data to each slave unit downstream, using the system's data communications network.
A
Each slave unit receives the transmitted package height, width and length data $\{H,W,L,V\}_G$ and converts this coordinate information into the slave unit's local coordinate reference system $R_{local\ I}$, $\{H,W,L,V\}_I$
B
The camera control computer in each slave unit uses the converted package height, width, length data $\{H,W,L\}_I$ and package velocity data to generate camera control signals for driving the camera subsystem in the slave unit to zoom and focus in on the transported package as it moves by the slave unit, while ensuring that captured images having substantially constant O.P.I. Resolution and 1:1 aspect ratio.
C
A

FIG. 32A

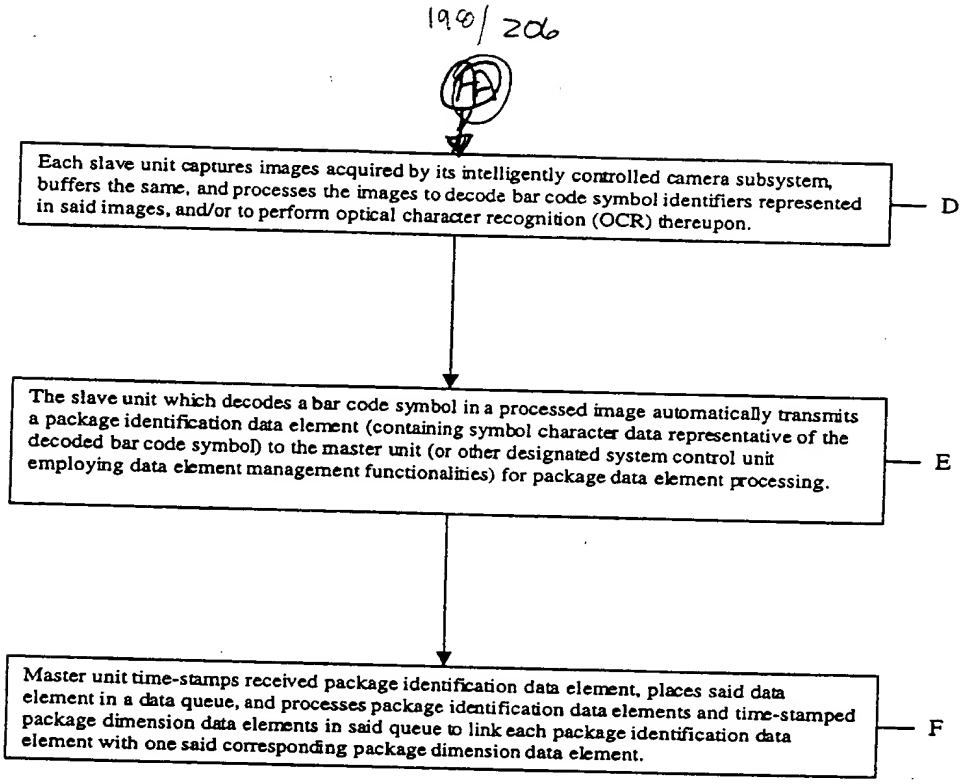

190/206
Each slave unit captures images acquired by its intelligently controlled camera subsystem, buffers the same, and processes the images to decode bar code symbol identifiers represented in said images, and/or to perform optical character recognition (OCR) thereupon.
D
The slave unit which decodes a bar code symbol in a processed image automatically transmits a package identification data element (containing symbol character data representative of the decoded bar code symbol) to the master unit (or other designated system control unit employing data element management functionalities) for package data element processing.
E
Master unit time-stamps received package identification data element, places said data element in a data queue, and processes package identification data elements and time-stamped package dimension data elements in said queue to link each package identification data element with one said corresponding package dimension data element.
F

FIG. 32B

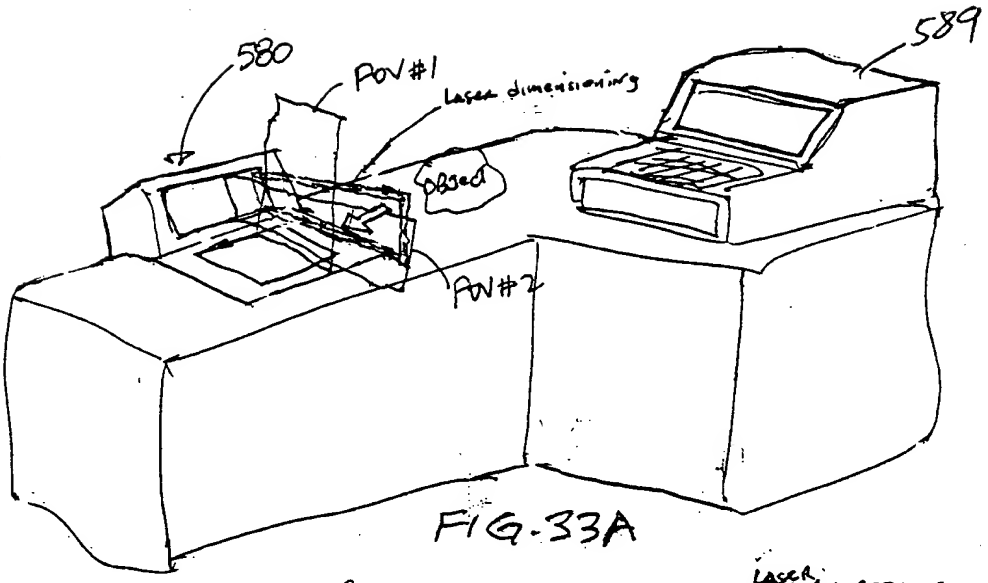


FIG. 33A

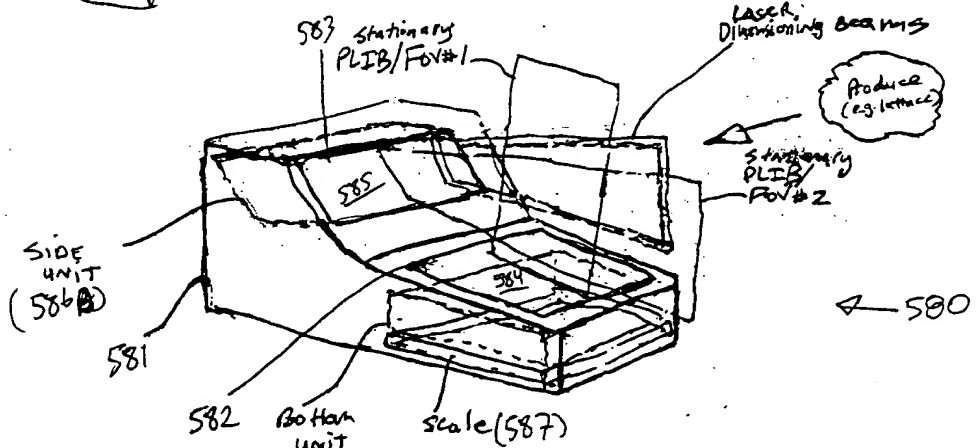


FIG. 33B

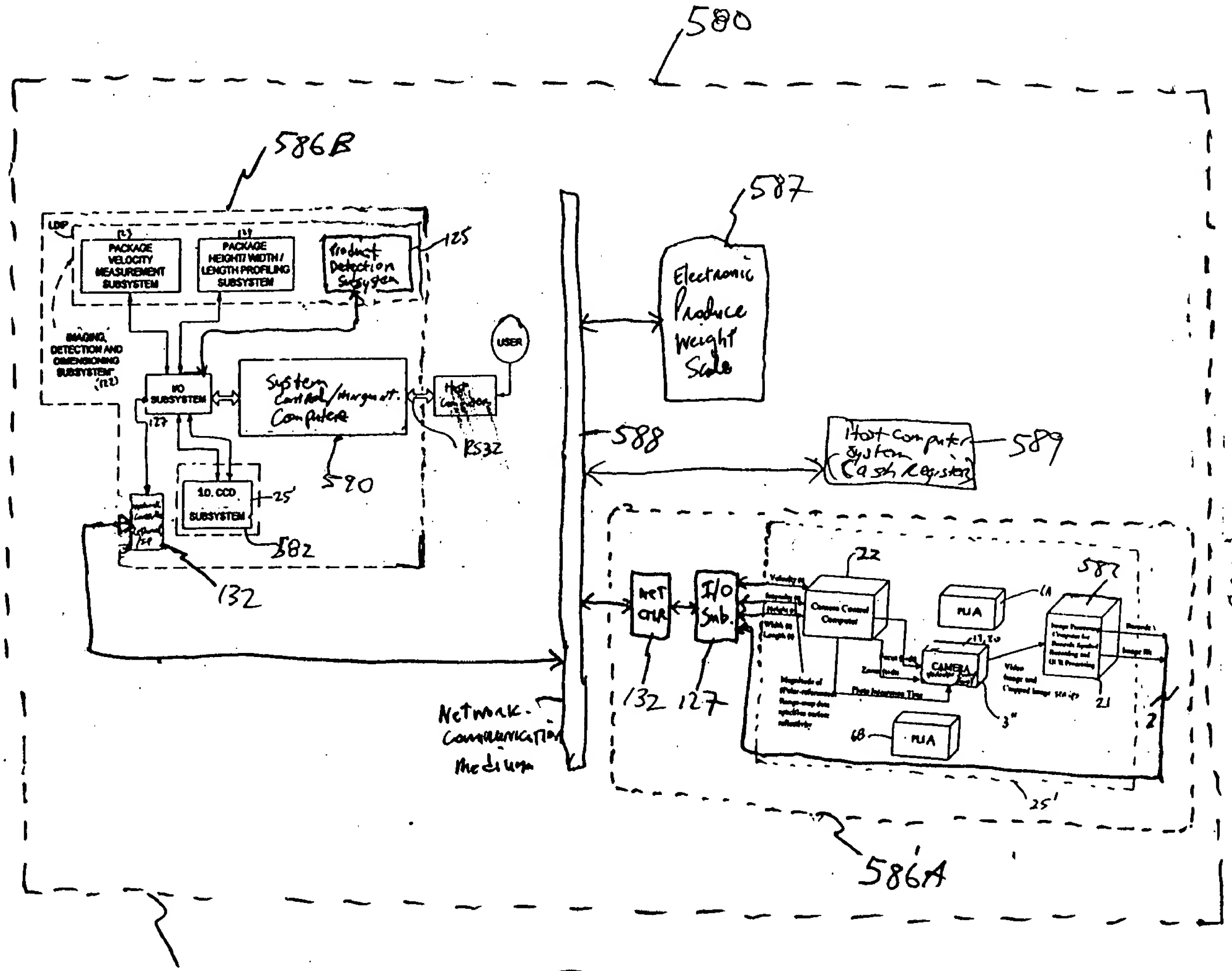

580
586B
PACKAGE VELOCITY MEASUREMENT SUBSYSTEM
PACKAGE HEIGHT/WIDTH/LENGTH PROFILING SUBSYSTEM
Product Detection Subsystem
125
IMAGING, DETECTION AND DIMENSIONING SUBSYSTEM
IO SUBSYSTEM
System Control/Mangmt. Computer
590
1D. CCD SUBSYSTEM
25'
582
132
USER
RS32
588
Electronic Produce Weight Scale
587
Host Computer System (Cash Register)
589
Network Communication Medium
NET CTLR
I/O Sub.
132
127
Camera Control Computer
22
PLIA
CAMERA
PLIA
6B
582
21
25'
586A
2

FIG.33C

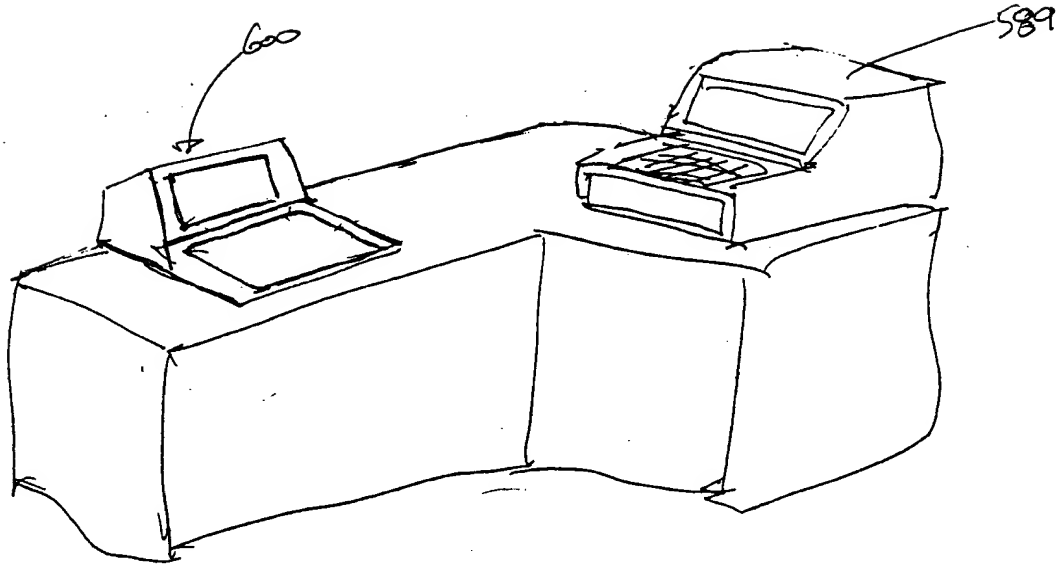


FIG. 34A

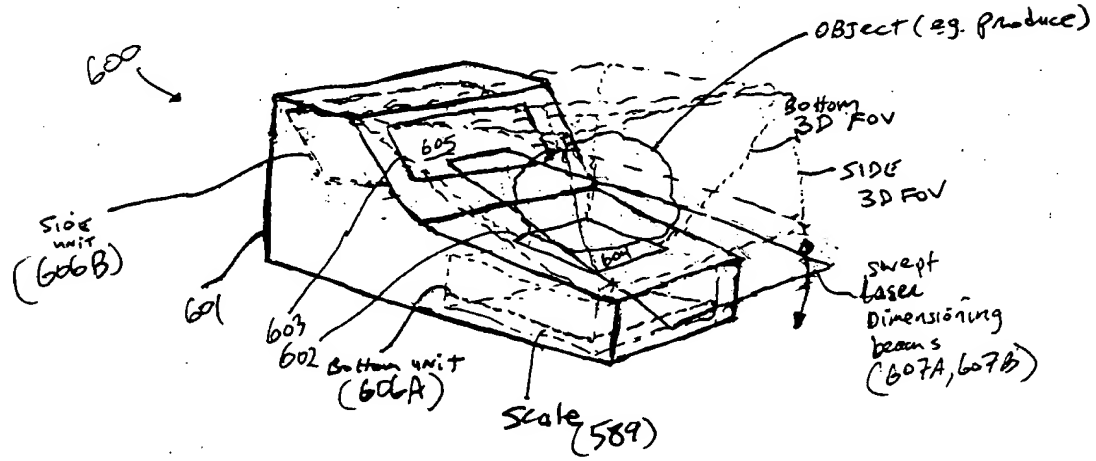


FIG. 34B

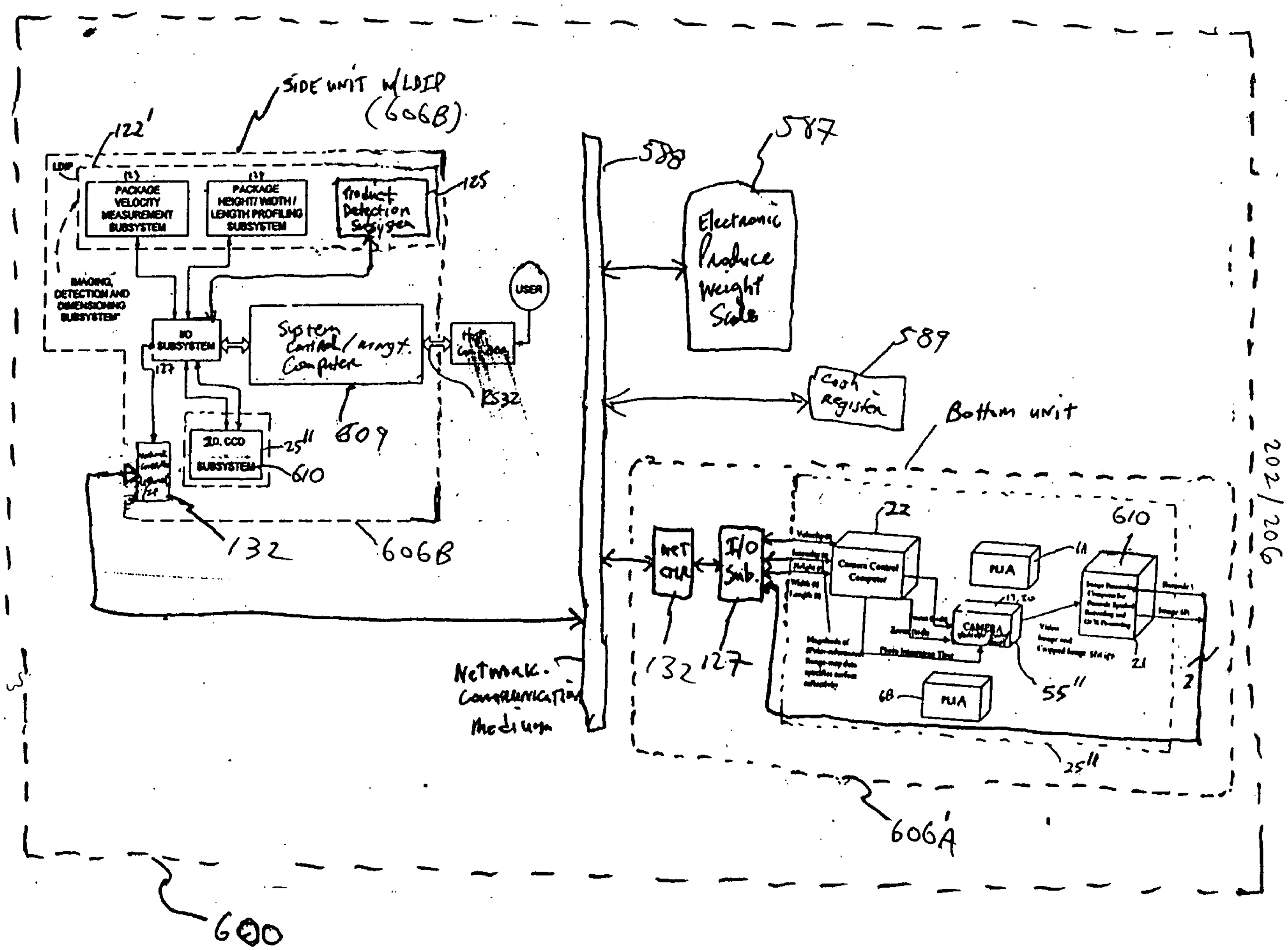

SIDE UNIT W/LDIP (606B)
122'
LDIP
PACKAGE VELOCITY MEASUREMENT SUBSYSTEM
PACKAGE HEIGHT/ WIDTH / LENGTH PROFILING SUBSYSTEM
Product Detection Subsystem
125
IMAGING, DETECTION AND DIMENSIONING SUBSYSTEM"
IO SUBSYSTEM
127
System Control / mngt. Computer
609
USER
RS32
2D. CCD SUBSYSTEM
25''
610
132
606B
588
587
Electronic Produce Weight Scale
589
Cash Register
Bottom unit
NET CTLR
I/O Sub.
132
127
22
Camera Control Computer
CAMERA
55''
NIA
610
21
2
25''
606A
Network Communication Medium
202/206
600

FIG. 34C

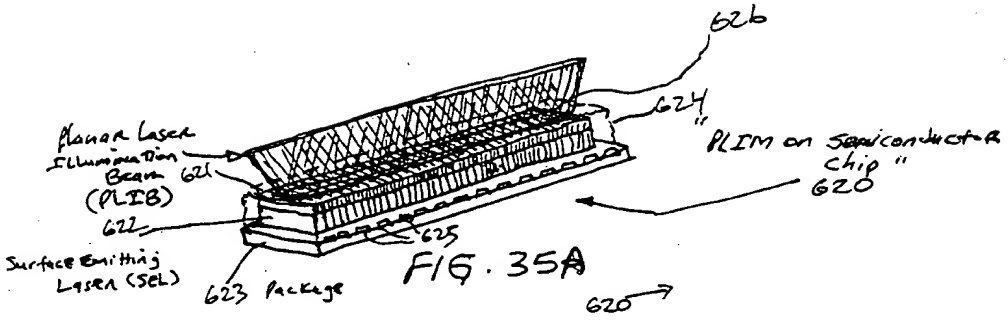


FIG. 35A

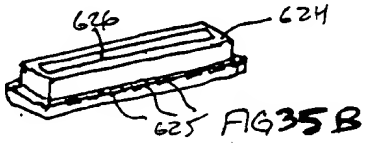


FIG 35B

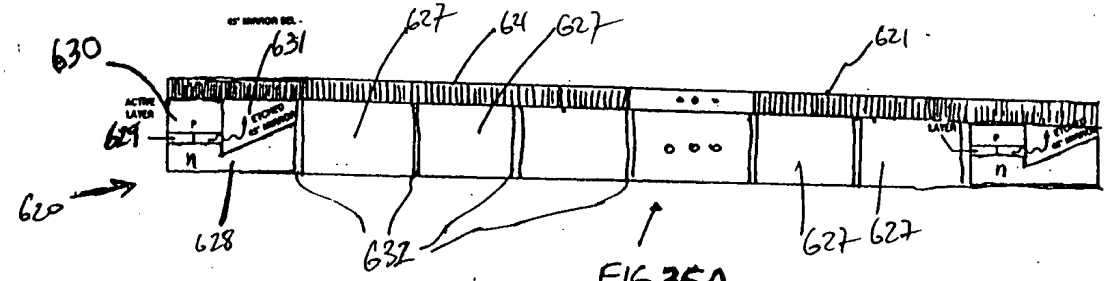


FIG 35A

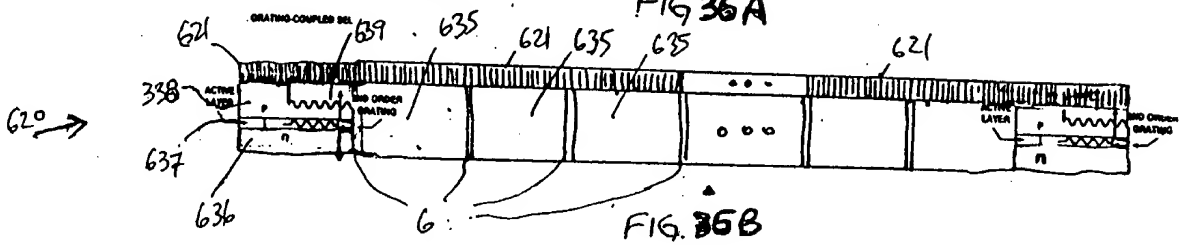
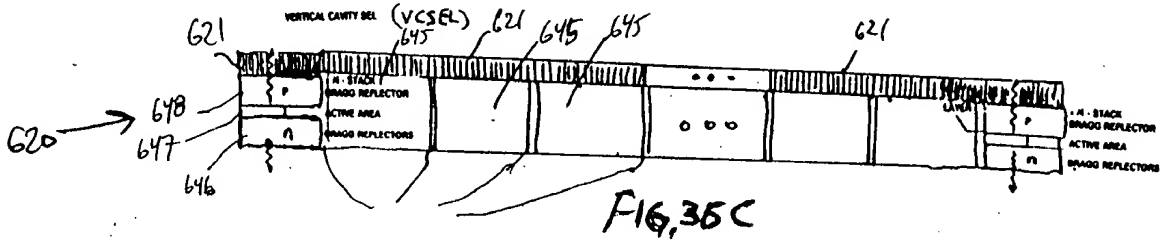


FIG. 35B



FIG, 35C

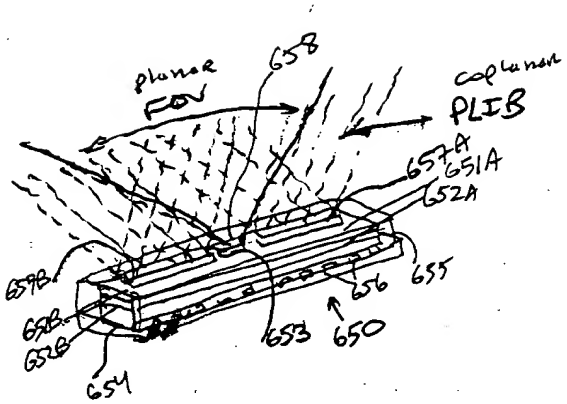

planar
FOV
658
coplanar
PLIB
657A
651A
652A
657B
655
656
652B
653
650
654

FIG. 37

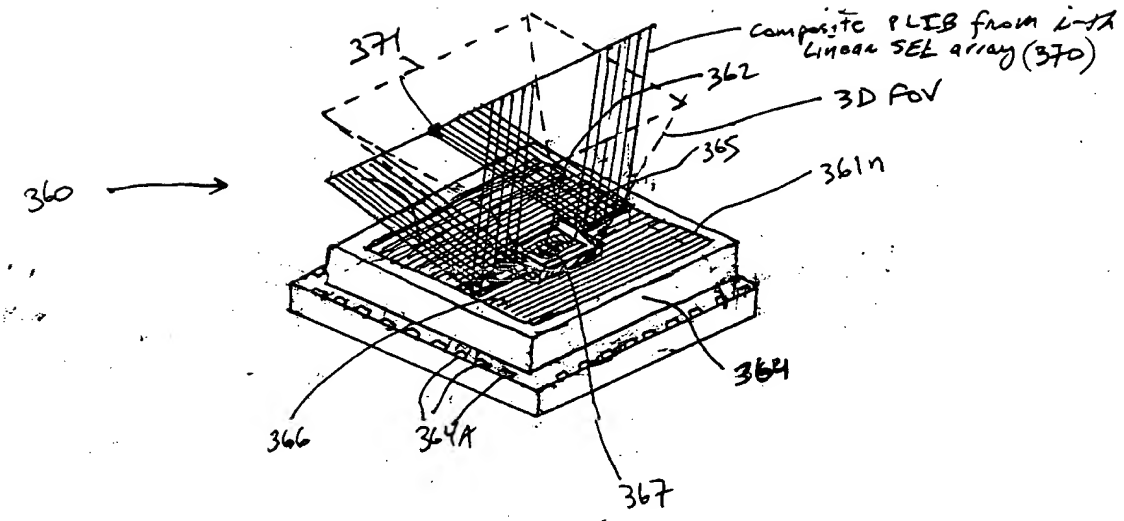


FIG. 38A

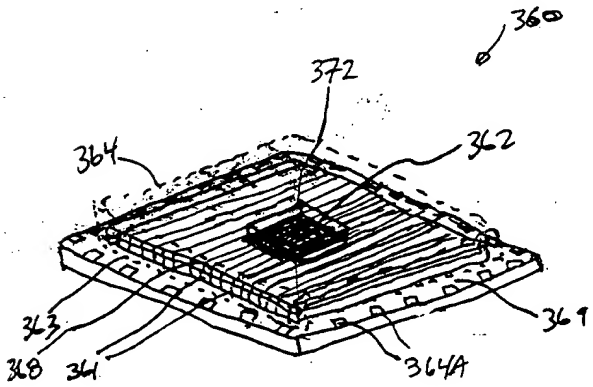


FIG. 38B